THE BRITISH NAVY.

VOL. II.

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THE BRITISH NAVY:

ITS STRENGTH, RESOURCES, AND ADMINISTRATION.

BY

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VOLUME II.

PART II.

MISCELLANEOUS SUBJECTS CONNECTED WITH SHIP-BUILDING FOR THE PURPOSES OF WAR.

Monstrum horrendum, informe, ingens, cui lumen ademptum.

LONDON:
LONGMANS, GREEN, AND CO.
1882.

PREFACE

TO

THE SECOND VOLUME

In presenting the second volume of this compilation to the public, it is my duty to explain that it was completed, in all its main features, before I joined the present Board. The statistics, as to the relative strength of the British and foreign navies, represent the situation as it existed two years ago. I have purposely refrained from correcting them, because it would be improper that official information should be communicated in a private publication. In the interval which has elapsed since the tables and the text of this volume were compiled important additions, as it is well known, have been made both to the armaments of the British Navy and to the number of our swift cruisers.

The figures in the chapter on the 'Strength and Resources of the Naval Powers' are those of the year 1879.

In the chapter relating to 'Unarmoured Ships,' the deficiency of speed in our medium classes is particularly insisted upon. It is stated in the text, but may here be repeated, that the data for comparisons between French and English vessels are taken from the report of Lieutenant Very, U.S.N., on the Exhibition held in Paris in 1878. During the last five years, and more particularly under the present Board, the requirements of the Navy, in reference to vessels of high speed, for the protection of commerce have been fully recognised.

While the statistics in this volume are, as it has been explained, considerably out of date, I have seen no reason to depart from any general views of naval policy which may be expressed in these pages.

It seems superfluous to repeat what has been said in the Introduction to this work, in praise of Mr. Barnaby and his able colleagues. Their task is full of difficulty, and it is accomplished with admirable skill.

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(*After Drawings by the Chevalier de Martino.*)

Errata

Page 21, line 19, saving in weight of turrets of 'Inflexible,' *for* 600 tons *read* 65 tons

Page 138, line 3, *for* glass *read* brass

„ 193, „ 36, *insert* the word 'not' in the sentence 'The out-rigger torpedo will, however, succeed'

CHAPTER I.

ARMOUR AND ARMOUR EXPERIMENTS.[1]

THE defensive armour, with which it has been customary of late to protect the heavy ships of modern fleets, may be considered with reference to its thickness, the material of which it is made, and the method employed in its manufacture; in other words, as to its intrinsic qualities. With respect to accidental circumstances, we have to look at the mode of its distribution and the system on which it is attached to the hull of the ship which it protects. These latter are points connected rather with arrangements of structure than with the strength of various descriptions of armour. Though ships' armour has been rarely subjected to the experience of real war, many questions referring to the resisting power of the plates composing it have long been experimentally settled. The history of armouring ships has, nevertheless, been progressive throughout; and since its first introduction there has been an advance not only in the thickness of the plates, but also in the mode of making them, and of fastening them to the hull. This advance now includes improvements in the material of which it is composed. The changes from time to time introduced into the manner of disposing protective plates upon the sides or other parts of a ship have been frequent and, occasionally, so important as to amount to a revolution in armoured-ship design. Viewed in its relation to the structure of vessels the armour question will be found fully discussed in another part of this work; though all allusion to

Various aspects of the armour question.

Advances made.

[1] LIST OF AUTHORITIES.—*Armour for Ships.* Institution of Naval Architects. By Mr. N. Barnaby, C.B.

On Armour-plating Ships of War. Institution of Naval Architects. By Admiral Sir R. Spencer Robinson, K.C.B.

Targets for the Trial of recent heavy Ordnance. By Col. T. Inglis, R.E.

Passage des Projectiles à travers les Murailles Cuirassées. Par M. Hélie. Paris, 1874.

On the Construction of Armour to resist Shot and Shell. Institute of Mechanical Engineers. By Capt. Orde Browne, late R.A.

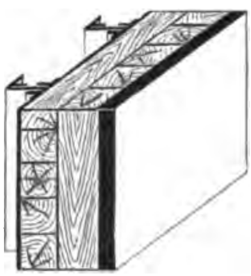
The Engineer, Engineering, United Service (American Quarterly), *Iron, Times,* etc., etc.

that aspect of it cannot be omitted in the present chapter. The general question is entering on a new stage; and there is now a *primâ facie* case for enquiry, whether the increased power of armour-piercing guns and the augmented thickness of plates, as well as the introduction of new material into its composition, have not created a set of conditions which no longer support previously received theories of penetration and resistance.

Early history of armour-plating.

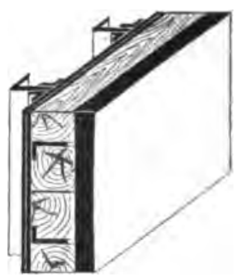
The Director of Naval Construction, Mr. N. Barnaby, C.B., has told us that the modern ironclad ship owes its origin to an imperial order of the French Minister of Marine, dated from St. Cloud, November 16, 1854. The course taken was to build floating batteries covered from end to end with iron plates. As the power of offensive weapons increased, so the plans of protecting ships had to be modified; and, as far as seagoing fleets are concerned, 'we have,' to quote Mr. Barnaby,[1] 'already proceeded far in stripping the armour from their sides and coming back to the old condition; but with this important difference: the vital parts of the fighting machine are protected against the enemy's guns to such an extent that no single shot or shell shall be capable of disabling it.'

Fig. 1.



'WARRIOR.'

Fig. 2.



'BELLEROPHON.'

Different systems of armour-protection.

Shortly after Mr. Barnaby had made the above statements, Admiral Sir Spencer Robinson read a paper[2] at the Institution of Naval Architects, giving a history of the several plans of imparting protection to ships, which had been tried or adopted since the construction of the 'Warrior.' (See fig. 1.) From that paper the following information is derived. The original idea of armour-plating was simply to attach to the part of the ship intended to be protected a plate of iron, $4\frac{1}{2}$ inches thick, in contact with two thicknesses of teak of 18 inches, secured by strong bolts to the skin of the ship.

[1] *Armour for Ships.* Institution of Naval Architects, April 1870.

[2] *On Armour-plating Ships of War.*

A modification was adopted in the construction of the 'Bellerophon,' 'which I believe,' says Sir Spencer Robinson, 'as long as the armour-plate is in one thickness, is in use up to the present time.' The armour-plates of the last-named ship were six inches thick, resting on a teak backing ten inches thick (see fig. 2) which formed a cushion in front of the skin of the ship consisting of two thicknesses of iron three-quarters of an inch each. At intervals of about two feet vertically along the armoured part of the ship a horizontal plate of half-inch iron was introduced. The outer edge of these strips alternately came into contact with the inner face of the armour-plate, or was cut off so as to allow an interval of one eighth or one quarter of an inch between the edge of the stringer plate and the armour. The inner edge of each strip was secured to the skin of the ship. The plates were in time made thicker, the teak backing deeper, and the horizontal strips of iron stouter. 'Still driven forward by the inexorable artillerists,' observes Sir Spencer, 'we find 14-inch iron plates backed by 15 inches of teak.' In the 'Inflexible' a thickness of 24 inches has been reached, with a 17-inch backing of teak.

Methods of armour-plating in use.

To the above rapid outline sketch of the progress of armour-plating may be added a summary of the methods of armour-plating given by Sir Spencer Robinson. They are four in number.

I. In this case the armour consists of a solid iron plate in one thickness, with more or less wood behind it, an inner skin and ribs behind the plate, and horizontal plates of thin iron between the thicknesses of wood.

II. The armour consists of two or more thicknesses of iron plate, with wood more or less thick between them, and the usual skin and ribs. These structures are generally known as 'sandwich'[1] armour.

III. The armour consists of an outer plate resting on an inner iron plate, either immediately in contact with the front or separated by a thickness of wood. This does not appear to have been adopted for ship-protection in England.[2] (See fig. 3.)

IV. This also has not been adopted for protecting cruising ships. In it an armour-plate of one thickness is supported throughout at its back by hollow rolled iron stringers filled with wood.[3] (See fig. 4.)

The 'air-space' or 'void-space' system has not been, and perhaps cannot conveniently be, applied to the protection of ships. In this system there are two thicknesses of armour separated by an empty space of considerable width. The room taken up by armour so disposed

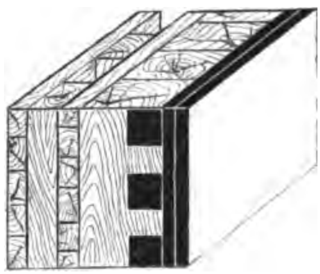
[1] Or 'plate-on-plate' armour.

[2] It has been adopted for some United States monitors.

[3] This principle has to some extent been adopted in the *popoffkas*.

would alone tend to prevent its adoption for most parts of a ship's hull or turrets. Even where the intervening space might be utilised as a passage or gangway, there are objections to its employment. Each layer of armour to be efficient should have its own backing and inner skin, thus doubling those found sufficient for other systems. The 'void-space' has no advantage over any other plan when attacked by steel projectiles, and under these circumstances, is inferior to the 'plate-upon-plate' system, in which the rear plate offers increased obstruction to the passage of the shot through the one in front.

Fig. 3.



U.S. S. 'COLOSSUS.'

Fig. 4.

'NOVGOROD.'

Though only two of the above methods have been actually adopted for armouring British ships, they are deserving of mention in the present work. So considerable has been the influence exerted by the practice of plating ships with protective armour in maritime warfare, that it has acted powerfully on the designs of military engineers. Coast fortifications are now frequently protected by the same material as ships, and according to some one of the methods described above. In addition to these we appear to be just on the threshold of the introduction of two novel plans of making the armour itself: viz. the composite plan, in which a surface of steel is laid upon a rolled iron plate; and the chilled or hard cast-iron system invented by Mr. Gruson of Magdeburg, in Germany.

General remarks on the attack of armour by shot.

Before proceeding to examine the qualities of existing armour on ships actually afloat or being built, and the behaviour of the several kinds when struck by shot, as shown by actual experiment, it will be well to offer some general remarks on the attack of armour by the guns now mounted in the vessels of the navy. When a shot is impelled from a gun by the explosion of a charge of powder, it moves forward with a certain velocity; and is said to have a certain quantity of 'potential energy,' or 'work,' stored up in it. When fired against a resisting object, such as an armour-plate, strong enough to stop, or bring the shot to rest, this 'work' or 'energy' is expended in several

ways. A portion of it is expended in putting the material fired at in motion; another portion in heating the plate.

Under certain circumstances the shot itself is heated; or a new motion may be imparted to the particles composing the shot, breaking it up or altering its form. The material fired at may be put in motion in different ways: it may be hurled forward entire, or portions of it may separate and permit the penetration or passage through of the whole or part of the shot. The temperature of a plate recently struck by a shot will be found to have been raised considerably, showing that some of the motion of the latter has been converted into heat. If the shot be composed of a material which permits of an alteration of form on violent impact, its temperature also will have been raised; whilst if it is composed of a material which is not subject to such alteration it will not have been heated, but will probably have been broken in pieces. Captain Orde Browne, R.A., says that, 'speaking generally, the destruction of armour is effected on two distinct systems, "punching" and "racking." On the first system the projectiles are driven completely through the armour, with the object of taking effect on the guns, men, and whatever else may be behind it. On the second system the armour itself is broken up and destroyed.' The second system—though in favour in some countries in the early days of armour-plating, when the heaviest guns mounted on board ship were smooth-bores, throwing heavy spherical shot with low velocities—has for some years been considered obsolete. The introduction of the new kinds of armour may, however, lead to its revival in a modified form. Wrought iron, in some shape or another, has been almost exclusively used for armour. Experiments have in general been carried out with that material, and our knowledge of the behaviour of other kinds is at present limited.

Solid wrought-iron armour.

Wrought-iron plates owe much of their value to the fact that they 'do not transmit the shock to the bolts and adjacent parts of the structure.'[1] A blow upon one of these plates is absorbed locally. They do not crack much if supported by proper backing, and may be penetrated comparatively easily. Judging from its general use in all navies, the shape of the projectile most in favour for armour-piercing guns is one with an ogival head. The length of this ogival head, or curved point, differs in different services. In the British it is formed by the intersection of two curves, struck with a radius of one and a half diameters of the shot; in foreign countries it is longer. This point finds its way through the plate fired at in a line with the prolongation of the axis of the shot. The head tears the plate open,

[1] Orde Browne.

and bends the adjacent portions aside. Directly the shot has impressed itself on the face of the plate, the back of the latter is bulged outwards to a height corresponding to the indentation in front. Further penetration of the shot causes a star, or two cross openings, to appear on the summit of the bulge. As it enters still further into the plate, the points of the sectors of a circle which meet at the intersection of the openings forming the cross, are bent backwards, and the head of the shot begins to appear emerging from the plate behind. Additional progress results in the tearing off the sectors, so that a patch, generally approaching a circle in form, is detached from the back of the plate. Thick armour-plates are made of several superimposed *strata*, or 'moulds,' of metal, which are submitted, when hot, to the action of heavy rollers that the various layers may be welded firmly together and the whole consolidated. On the amount of success attending the operation of rolling depends, to a great extent, the power of the plate to resist perforation and the quantity of 'mould' knocked off from the back. If the union between adjacent layers is imperfect, that at the back can be more readily carried off by the head of the shot; and as the whole plate bends to the blow and the bulge rises behind, the imperfectly welded parts slip past each other and offer less resistance to the advancing shot. From this it will be at once seen that laminated armour, or armour composed of separate plates of a limited thickness placed one on top of the other, may be expected to prove inferior to solid armour of the same total thickness. This has been found to hold good in actual experiments; and it was some years ago estimated that six inches of laminated armour was equal only to a 4-inch solid plate. An ill-made thick armour-plate is consequently likely to fail because of the imperfection of the workmanship, even though its material be good.

Laminated armour.

Sandwich armour.

Between solid and laminated armour there is an intermediate plan, noticed above as the 'sandwich' or 'plate-upon-plate.' It is thought to be very doubtful if solid plates of the great thickness required of late to stop penetration by shot fired from the newer guns, could be rolled as perfectly as those of less dimensions. And it is, therefore, a question if two or three well-made stout plates are not superior, or at least equal, to a single plate of the same total thickness. When of certain dimensions, which are far from inconsiderable, the single plate has been proved to be the best. Colonel Inglis, R.E., says: 'I think it may now be fairly assumed that a solid rolled iron armour-plate 17 inches or 17½ inches in thickness is equal, as regards resistance to perforation, to three 6½-inch iron plates separated by 5-inch layers

of teak.'[1] But it has not been shown that the same superiority is maintained when a greater thickness is required. There is, moreover, one advantage on the side of the plate-on-plate system which is peculiar to it; and that is, that the joints between the plates of one layer can be made to occur so as not to be opposite those of another layer.[2] Each plate can also be more easily bolted and secured in place.

Composite armour. These advantages have led to the introduction of composite armour into the service for armouring turrets; and those of the 'Inflexible' have two layers of armour separated by an interval of wood on the 'sandwich' system. The outer of the two plates on the turrets of that ship are 'composite;' that is, made of wrought iron faced with steel, the whole being rolled and welded together. Plates of this kind are made by both of the two great Sheffield firms—Cammell and Co. and Sir John Brown and Co. Those of the former are made under the patent process of Mr. Alexander Wilson. It consists in heating the iron plate in a specially constructed furnace to a certain degree of redness, and—while in the furnace—in pouring upon it the molten steel to the required thickness. The steel has a much higher temperature than the iron plate, that of the latter being comparatively low. The excess of heat in the steel beyond the welding temperature of the iron serves to bring up the surface of the latter to a welding heat. The carbon in the steel carburises the iron to a depth of from $\frac{1}{8}$ inch to $\frac{3}{16}$ inch, thus forming a zone of mild steel between the hard steel and the iron, which constitutes an inseparable weld. Brown and Co.'s process differs slightly in some of its details, but the principle of construction is the same. To combine iron and steel together is to effect a union of hardness and toughness. Judging from experiments, hard steel alone has not proved a very efficient protection against shot. It has a tendency to 'star' and crack upon the impact of shot from modern guns, and has proved on that account but a poor substitute for rolled iron, which—if unable to resist the penetration of shot equally well—has the advantage of localising the injury done to it instead of breaking up. There have as yet been comparatively few experiments against composite armour-plates. The general result has been that the steel, when struck, breaks up the projectile of a gun—the penetrating power of which is not very greatly superior to the resisting power of the plate—more readily than rolled iron would do. The plate is not perforated, but the steel

[1] *Targets for the Trial of recent Heavy Ordnance.* Part III., 1877.

[2] The bulge in rear of the front plate made by a projectile is also checked by the plate behind, and the shot's passage impeded.

face becomes much cracked and even broken, though it is retained in place by its union with the tougher layer of iron behind. Unless, therefore, the same plate be struck repeatedly—of which there would be but small probability in a naval action—the difficulty is greater of getting a projectile through such a plate than through one wholly of iron of the same, or even of somewhat greater, thickness. It would be premature as yet—until more experiments have been made—to attempt to estimate the value of the new armour as a protecting material against the more recent guns; but it seems likely that against those which have long been considered armour-piercing pieces, as our 12-ton and 18-ton guns, steel-faced plates will have a resisting value probably one-fifth greater than iron, or even more.

Armour-piercing shot.

Closely connected with the subject of armour-material is that of material for armour-piercing shot. The power of a gun designed to attack armour is generally measured by the energy with which it sends forth its projectile. Yet its real efficiency must depend to a great extent on the efficiency of the projectile itself. The material of which the latter is composed should be hard, that it may retain its form; and tough, that it may not fly to pieces at the moment of impact. If a shot 'sets up' through excess of ductility, or is shivered at the first shock, owing to its want of cohesion, its power of penetrating armour is diminished. A portion of the 'work,' in fact, which should be done on the armour is done on the shot, and it is the latter as well as the armour, and not the armour only, which is damaged. It has already been said that the form of projectile for armour-piercing which is most in favour, is that with an ogival point. Other forms have their advocates. Of these the flat-headed is the most important, though for some years it has been generally disregarded for the ogival. 'Theoretically,' says Captain Orde Browne, 'the flat-headed shot ought to get through a plate with less resistance than the ogival; and this may be pleaded in favour of the former, where an unbacked plate is fired at. Obviously, however, the rough disc of iron, which is driven out in front of the flat-headed shot, meets with enormous resistance, as it gets foul in the backing; while the clean point of the ogival-headed shot cleaves its way easily through backing and skin.' Many experiments have been carried out in England and elsewhere with the view of settling the best form of projectile and the best material of which to make it. In many cases the results have not proved very satisfactory from want of regularity; a fact which has to be borne in mind when estimating the effect of all armour-piercing projectiles. 'The determination of the energy (*force vive*) exerted by the passage of a projectile through an armoured

wall is of great importance to the navy,' says M. Hélie;[1] 'it is, however, one of those questions which we can hardly hope to treat in a really satisfactory manner. The quality of the armour-plates varies, and the walls, to which they are secured, do not always offer the same resistance. And the shot, generally of steel or chilled cast-iron, undergo deformations which vary one from another.' Sometimes at the moment of impact the axis of the projectile departs somewhat from the normal to the plate, and the penetration is diminished. Till lately it was generally believed that the best material for armour-piercing projectiles was chilled cast-iron; but very recently tempered forged steel has been coming into favour.

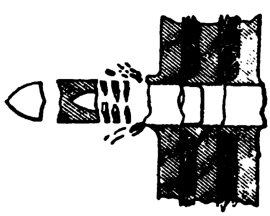
Recent armour-plate experiments.

That an idea may be formed of the behaviour of the various kinds of armour when struck by shot, it will be well to give some account of the more important experiments of late years, and of those few engagements in which armoured ships have taken part, which furnish evidence of the effect of gun-fire upon their iron-protection. Colonel Inglis, R.E., whose authority in all matters connected with iron armour for ships or forts is second to none, has described several of the more remarkable experiments.[2] The descriptions given by him may be quoted here.

38-ton gun at a sandwich target.

He says, a 'target, known as No. 40, and intended for the trial of the 12½-inch 38-ton gun, has been erected at Shoeburyness, and one round has been fired against it. This target consists of three 6½-inch plates set up one behind the other at intervals of 5 inches. The intervals are filled with two layers of 2½-inch teak planking, laid crossways, and held together by ⅝-inch coach-screws 4½ inches long. Each plate is 10 feet long and 8 feet wide, and weighs in its finished state about 9 tons 3 cwt.' (See fig. 5.) The whole is secured to a timber structure and rests upon a bed of concrete. There is, therefore, in the target a total thickness of iron of 19½ inches and of teak of 10 inches. 'The first object in view,' continues Colonel Inglis, 'was that of obtaining an exact measure of the power of the 38-ton gun of 10½-inch calibre, firing its service Palliser projectile of 800 lbs. with its proper battering charge of 130 lbs. of 1·5 inch cubical powder [known as P²], at the shortest practicable range. An amount of armour was, therefore, provided which it was thought

Fig. 5.



[1] *Passage des Projectiles à travers les Murailles Cuirassées.* Paris, 1874.

[2] *Targets for the Trial of recent Heavy Ordnance.* London and Chatham, 1877–78.

would only just stop this shot, and the problem was so exactly solved by the one round fired, that, while the head and part of the body of the projectile passed through the target, a portion of the base end was arrested and remained in the hole.' The gun was placed 70 yards from the target, and the shell struck fair with a velocity of 1,420 feet per second, and a total energy or *vis viva* equivalent to about 11,400 foot-tons. 'It made clean holes, 12½ inches in diameter, through the front and middle plates, and formed a hole of the same diameter part of the way through the rear plate, knocking off the back moulds of this plate to a depth of 4 inches, the area of injured surface in rear measuring 2 feet 4 inches by 2 feet 3 inches. The head of the shell was picked up in rear in an entire state, the point being uninjured and the form of the head unaltered. The main part of the body, which also passed through the target, was found broken into a few large pieces.'

Fig. 6.

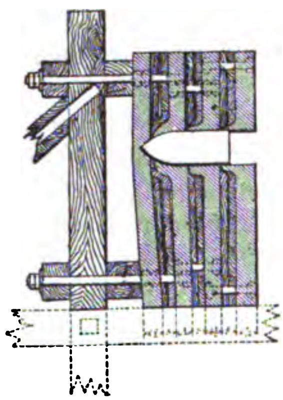
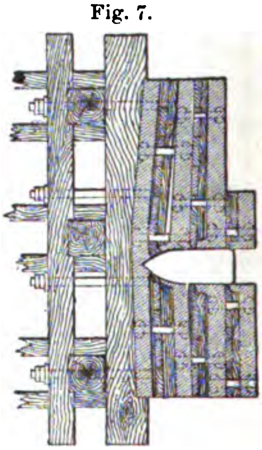


Fig. 7.



38-ton 'chambered' gun at a sandwich target.

The target was afterwards strengthened by the addition of a fourth 6½-inch plate in front, with 5 inches of teak between it and the one behind it, being the same thickness as in the intervals between the other plates. The same nature of gun, the 12½-inch 38-ton, was selected to fire at the new target. The gun actually used had been 'chambered;' that is to say, the inner portion of the bore had been enlarged, so as to admit of a charge of 200 lbs. of P^2 powder being used. The effect of chambering is not only to allow of a considerable increase in the dimensions of the cartridge and in the weight of the powder, but also to diminish the pressure on the gun and augment the velocity of the shot. This subject will be found more fully noticed in the chapter on Guns. The target now contained 26 inches

of iron and 15 inches of teak. The projéctile struck it with a velocity of 1,525 feet a second, and a total energy of 13,080 foot-tons. 'On entering the front plate,' says Colonel Inglis, 'the shell felt the least resistance to be on its proper right side, and therefore turned in that direction about 5° from the perpendicular. It penetrated the target till its point got somewhat less than an inch into the back plate.' (See figs. 6 and 7.)

Few armour-plate experiments in England are more memorable

Fig. 8.

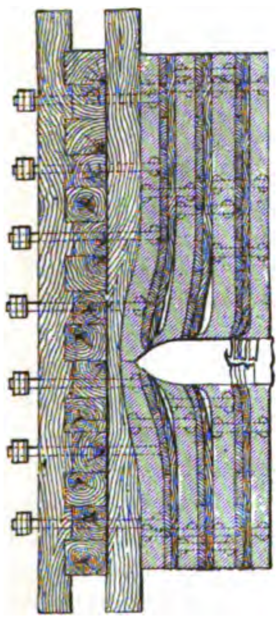
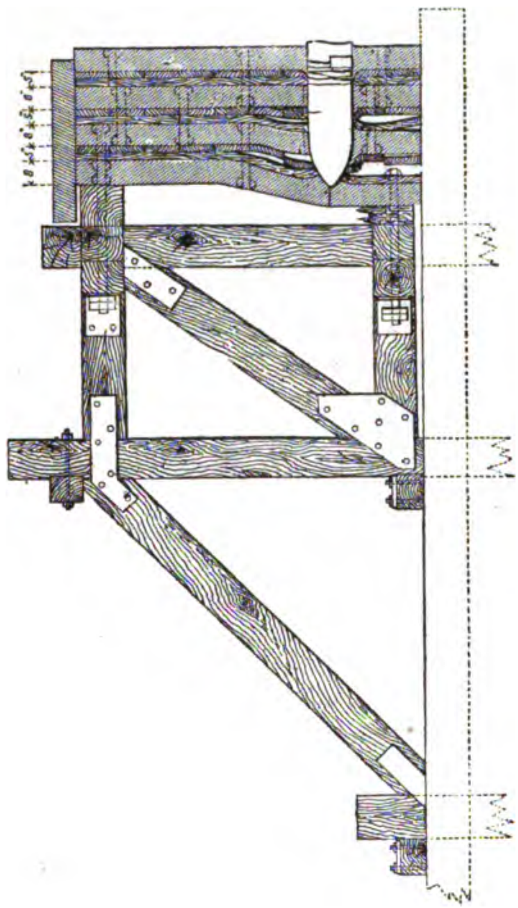


Fig. 9.



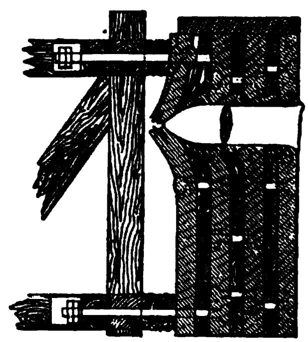
than those in which the 80-ton gun was fired against sandwich targets. In February, 1877, when its bore was of uniform diameter, it was fired with a projectile weighing 1,700 lbs., and a powder charge of 370 lbs., against a sandwich target composed of four eight-inch plates, with five inches of teak between each pair. (See figs. 8 and 9.

The muzzle of the gun was 118 feet from the target. The projectile struck the latter with a velocity of 1,496 feet a second, and a total energy of 26,400 foot-tons. The blow was delivered at an angle of about $1\frac{1}{2}°$ from the perpendicular, and the shot 'turned a little more in penetrating the target, so that its final inclination was $2\frac{1}{2}°$ to the left, and it turned also about 2° downwards.' Out of the 32 inches of iron of which the target was composed the point of the projectile actually penetrated about 25. The head remained entire in the hole and immovable; and about 11 inches of the rear part of the body broke up in the hole.

'Chambered' 80-ton gun at a sandwich target.

A few months later the chambered 80-ton gun was fired at the same target, the projectile being the same as before, and the powder charge being increased to 425 lbs. The striking velocity was 1,585 feet a second, and the total energy was equivalent to about 29,615 foot-tons. Colonel Inglis observes on this experiment: 'The actual penetration of the point of the shell into the armour in this round is only one-third of an inch more than that in the former round; but the total penetration, measured from the face of the target, is 7·4 inches more, the difference being accounted for by the greater amount of bulge in rear.' (See fig. 10.)

Fig. 10.



Common shell at armour-plates.

It will be convenient to notice here a somewhat remarkable experiment, showing how poor a protection is afforded by plates of considerable thickness against even the common shell of the heavier guns of the present day. A common shell weighted up to the same amount as the armour-piercing projectile, viz. to 1,700 lbs., was fired from the 80-ton unchambered gun, with a charge of 370 lbs. of P^2 powder at an unbacked plate 8 inches thick, 140 yards from the gun. The shell passed completely through the plate, making a hole 20 inches in diameter. A common shell weighing 400 lbs., containing a bursting charge of 26 lbs., was fired from the 10-inch 18-ton gun with a powder charge of 70 lbs. of pebble-powder at a 5-inch unbacked plate 70 yards distant. The shell went through the plate, breaking up in its passage. The explosion appeared to take place after it had got through the armour. A second round was fired, in which all the conditions were similar to those in the last, except that there was a percussion fuze in the shell. The bursting of the shell,

which was evidently caused by the fuze, occurred at the moment of its passing through the plate. 'These rounds,' says Colonel Inglis, 'will help to correct the mistaken notion which has been very general, that only a slight thickness of armour is necessary for keeping out common shell.'

'Air-spaced' armour-plates.

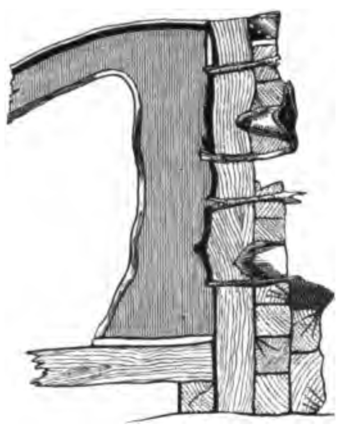
Some interesting results have been obtained in experiments with armour composed of two thicknesses, separated by an unoccupied interval, or, as it is called, an 'air-space,' when the armour was attacked by chilled cast-iron projectiles. But this method of protection is perhaps not applicable to ships, resembling in this particular the cast-iron armour of Mr. Gruson, of Magdeburg.

Experiments at Spezia in 1876.

The important experiments carried out at Spezia by the Italian naval authorities at the trial of the 100-ton gun are described in full detail in another part of this work. In addition to the interest attaching to them as experiments in artillery, they are particularly worthy of attention as tending to throw light upon the question of the best material for defensive armour. Colonel Inglis has very fully described these interesting trials, and the following account is borrowed from his description. The undermentioned targets were fired at:—

Fig. 11.

Fig. 12.

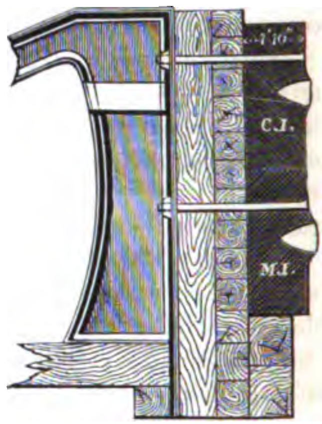


1. A target consisting of two front plates of soft hammered steel $21\frac{3}{4}$ inches thick backed by 28 inches of oak, in which there were horizontal iron stringers of $\frac{1}{2}$-inch plate, covering a skin of two thicknesses of $\frac{3}{4}$-inch plate. (See fig. 11.)

2. A target composed of two wrought-iron armour-plates of nearly the same thickness as No. 1, with the same arrangement of backing.

One plate was rolled by Messrs. Cammell and Co., of Sheffield, and the other was made by Messrs. Marrel, of Marseilles. (See fig. 13.)

Fig. 13.



3. Two 'sandwich' targets, each consisting of a front plate of iron 11·8 inches thick, with horizontal timbers 12 inches thick behind it, then a second plate 9·8 inches thick with 16 inches of wood behind, and skin and frames as before. (See figs. 14 and 15.) The armour of one was rolled by Messrs. Cammell and Co., that of the other by Messrs. Marrel.

4. Two targets, placed below the sandwich targets just described (see figs. 14 and 15), consisting in front of 7·8-inch wrought-iron plates made by Messrs. Marrel, backed by blocks of Gregorini chilled cast-iron 13¾ inches thick. Each armour-plate had four of these blocks behind it; in one case (see figs. 14 and 15)

Fig. 14.

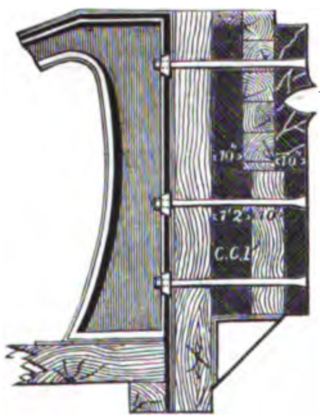
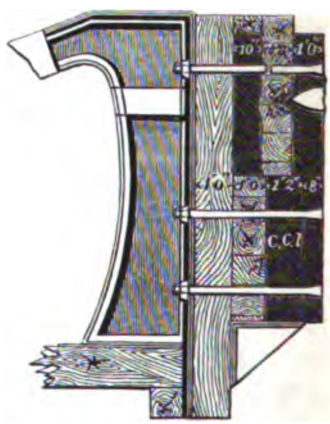


Fig. 15.



the chilled blocks came next behind the armour, in the other 12-inch timbers were interposed.

5. In addition to these there was a rolled armour-plate 21¾ inches thick, made by Messrs. Brown, of Sheffield.

The guns used in the experiment were the following:—A 10-inch gun of a little over 18 tons' weight, which threw a Palliser projectile of 397 lbs. with a charge of 77·2 lbs. of powder; an 11-inch gun of 25½ tons, which threw a Palliser projectile of 531 lbs. with a charge

of 94·6 lbs.; the 17-inch 100-ton gun, throwing a projectile weighing 2,000 lbs. with charges ranging up to 374 lbs.

Beginning with the first target, the upper steel plate received first a shot from the 10-inch gun with a muzzle velocity of 1,401 feet in a second. The depth of the indentation made was about 11 inches The plate was cracked to the bottom edge, and, as generally happens when steel plates are struck by projectiles, began to 'sing,' or make a sharp crackling noise, and another crack gradually opened. It was again struck by a projectile from each of the two guns, the 10-inch and the 11-inch, fired simultaneously. The end of the plate was broken away and fell in three principal fragments; the singing was again heard, the cracks formed by the first shot were extended, and a fresh crack appeared. The next round fired at the plate was from the 100-ton gun. The muzzle velocity of the projectile was 1,495 feet a second. The point entered 21 inches into the steel and completely broke up the plate, only two pieces of it remaining on the target structure. The rest of it was thrown away in pieces varying from one to three tons in weight. The shell[1] penetrated deep into th backing, but did not perforate it. A round similar to the last was fired at the lower steel plate on the first target, the velocity this time being about 1,476 feet a second. The plate was completely broken up by this final round, about one-half of it being knocked off, the rest being left hanging by some armour-bolts.

The next experiment was against rolled iron armour-plates of the same thickness as the steel, the iron being subjected to the same rounds as was the latter material. The 10-inch shell indented the plate manufactured by Messrs. Cammell and Co. 10·8 inches. The 10-inch and 11-inch shells fired together struck near the end of the plate, and broke a piece off near a corner. The indentations were 17·75 and 13 inches. The projectile from the 100-ton gun struck the plate so near the bottom edge that but little was to be learned from this ineffective round. Messrs. Marrel's plate on this target was attacked by similar rounds. The first 10-inch shell indented it to a depth of 11 inches. The 10-inch and 11-inch shells fired at the same time penetrated 12½ and 14½ inches into the plate and broke off an end, which remained hanging till the next round. The shell from the 100-ton gun indented the armour 23 inches, the rear mould, 5 inches thick, being broken off over a circle 3 ft. 6 in. in diameter.

[1] Though the words 'shot' and 'shell' have been used indiscriminately in describing these armour-plate trials, it should be said that the projectiles fired were really shell, but without any bursting charge.

All the upper part of the plate was carried away, and the rest of it broken to pieces. (See figs. 16 and 17.)

The plate furnished by Messrs. Brown and Co., of Sheffield, was fired at four times with the 100-ton gun, the first round, taking effect

Fig. 16.

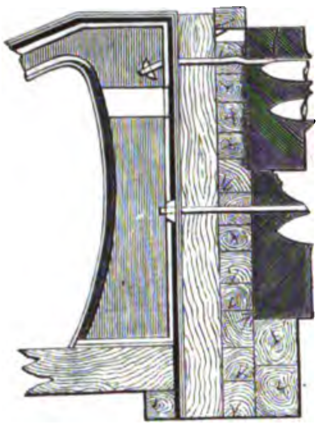
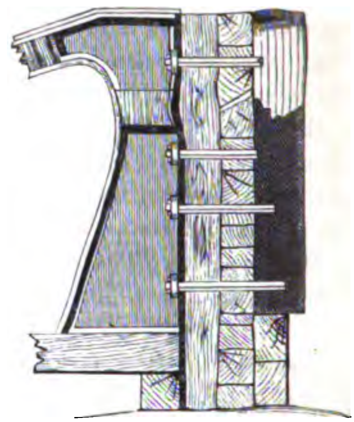


Fig. 17.



on the very edge of the plate, was useless for comparison. The next round, fired with a diminished charge, made an indentation of 15·2 inches deep, and broke off a piece of the plate. The third round with a higher charge went completely through the target. The

Fig. 18.

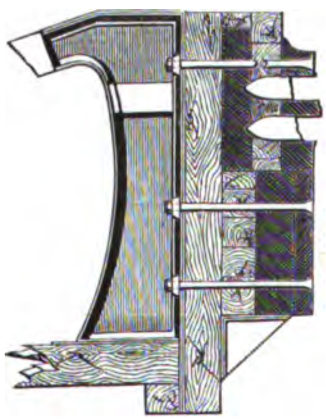
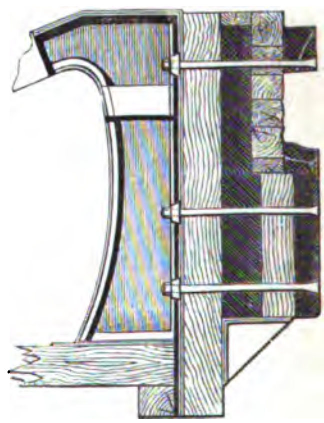


Fig. 19.



point of the fourth shell, fired with a diminished charge, penetrated 15 inches into the armour and split the plate.

In the practice at the sandwich plates, Messrs. Cammell's armour was first struck by a 10-inch shell, the point of which penetrated

13 inches from the front. The two shells (10- and 11-inch), fired together, broke the front plate across, the lower corner being thrown off, and each indented the inner plate 2⅜ inches. The shell from the 100-ton gun, fired with a moderate powder charge, passed through the front plate, and penetrated to a depth of 6·7 inches into the rear plate. The same rounds were then fired at Messrs. Marrel's plates on this sandwich target. The 10-inch shell made an indentation into the front plate 9⅝ inches deep, and cracked it across. Of the two shells fired together, the 11-inch passed through the front and indented the inner plate 2 inches; the 10-inch indented the front armour 13 inches. The front plate was much cracked, and pieces of it were quite detached. The shell from the 100-ton gun broke both plates. (See figs. 18 and 19.)

A shell from the 100-ton gun, fired at the wrought-iron plate,

Fig. 20.

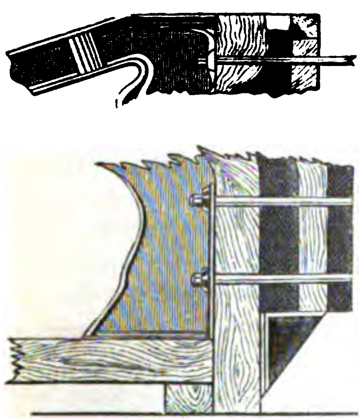
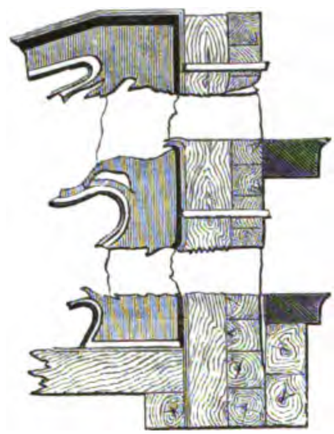


Fig. 21.



between which and the block of cast-iron was a filling of 12 inches of wood, punched a large hole through the wrought-iron, broke the cast-iron into fragments, 'which, being propelled onwards, burst through the structure in rear, and formed a great hole about 6 feet in diameter in what would have been the ship's side.' A similar round disposed of the target in which the wrought and cast-iron were superimposed the one on the other. (See figs. 20 and 21.)

The effect of shot on 'composite' or 'compound' armour has been investigated by experiment in England. In July 1877 two small plates made by Messrs. Cammell and Co. were tested at Shoeburyness. The one had a 5-inch face of hard steel containing ·64 per cent. of carbon, welded upon four inches of wrought iron, and was hammered; while the other, which was rolled, consisted of 4½ inches Composite armour experiments.

of somewhat softer steel, containing ·48 per cent. of carbon, and 4¾ inches of iron. Both plates were made by heating 7-inch rolled iron plates to a good red heat, and quickly transferring them to a cast-iron mould or box. Molten steel was then poured upon the wrought iron to a depth of eight inches, so that the combined ingot thus formed was 15 inches in thickness. The several makes were then reduced by hammering and rolling to the finished thickness of nine inches. Each plate was tested with 7-inch Palliser shot weighing 113 lbs., and was attacked, at thirty yards, with charges of 30 lbs. of pebble powder. The hard plate was the first fired at. The projectile broke up in its head as well as in its body, the plate being scored all over its face by the flying fragments. The diameter of the shot mark was 9½ inches; the point of the shot had penetrated little more than three inches, whereas with the same energy in striking it would, in a wrought-iron plate of the same thickness, have reached to a distance of twelve inches from the face of the plate. The plate with the soft steel face was indented to a depth of nearly 5½ inches, and the shot, though broken, was not so thoroughly destroyed as in the previous experiment. Steel shot have been used to test this composite armour. A plate of four inches of steel and six inches of ordinary iron armour was unbacked and unsupported, and the gun used was the 9-inch 12-ton gun at fifty yards. The weight of the projectiles was 268 lbs. In the first round a Whitworth fluid compressed steel shell indented the plate to a depth of 10½ inches, producing a considerable crack at the back. Though the face was cracked the steel adhered to the iron. The projectile was much set up. A cast steel shell of Messrs. Cammell's manufacture was fired at the same plate and went completely through it, the head being broken into three pieces and the body into several more. The steel face of the plate was more or less cracked, but still continued to adhere to the iron.

At Shoeburyness in the same year two compound plates manufactured by Messrs. Brown and Co. were tried. They were made by heating hard masses of Bessemer steel and wrought iron in an ordinary furnace, and rolling them down to five inches in thickness, borax being used as a flux. The steel and iron were in equal parts, the former containing ·5 per cent. of carbon. One plate was hardened and the other unhardened. Fired at with a Palliser shell of 113 lbs. from a 7-inch gun with a diminished charge of 8½ lbs. of R. L. G. powder, the hardened plate was indented 3⅓ inches at thirty yards, or about half the depth of the usual indentation from the same blow on a rolled iron plate of five inches. With a charge of 25 lbs. of pebble

powder a 7-inch shell just forced its point through the plate and broke up. The unhardened plate offered a less satisfactory resistance.

In 1879 further experiments were carried out at Shoeburyness with 14-inch wrought-iron armour in comparison with 12-inch compound armour, both being unbacked. The average penetration into five steel plates was about $6\frac{1}{4}$ inches, and into eight iron plates $13\frac{1}{4}$ inches. The armour for the 'Inflexible's' turrets was tested during the same year at Portsmouth. The plates have a thickness of nine inches. Upon a 9-inch plate of iron five inches of liquid steel, high in carbon, was poured, making the whole fourteen inches thick. This was rolled down to 9 inches, $3\frac{1}{2}$ inches of steel and $5\frac{1}{2}$ of iron. The 9-inch Palliser projectiles were fired at these plates, and broke up in every instance. The turrets of the 'Inflexible' were originally to have been armoured with solid plates 18 inches thick; but compound armour having been adopted, the same weight of metal is not required. The total thickness is now only 16 inches, viz. an outer ring of 9-inch compound armour, and an inner ring of 7-inch iron plates. The saving of weight, without diminution of protection, will amount to something like 600 tons. In the 'Ajax' and 'Agamemnon' the compound armour of the turrets is to be of one thickness of 16 inches, there being a layer of $5\frac{1}{4}$ inches of steel on $10\frac{3}{4}$ inches of iron. This is to be tested by the 38-ton gun. There appears to be an intention of applying compound armour of 18 inches thickness to the sides as well as to the turrets of some vessels which have recently been laid down for our own Government. The sides of the 'Almirante Brown,' built by Messrs. Samuda for the Argentine Republic, are protected with this material.

Whitworth's steel deck-armour.

Some very remarkable steel armour has been manufactured by Sir Joseph Whitworth for the deck of the torpedo-ram 'Polyphemus.' The inner strake consists of plates of mild steel, six feet long, 30 inches wide, and an inch thick. Upon this is placed a hard face, consisting of 10-inch squares of very hard steel, also an inch in thickness. The double plate is laid over iron deck-plating of $2\frac{1}{2}$ inches in two thicknesses. The advantage of the composite protection would apparently be greatest in cases—naturally most likely in actual combat—when the projectile strikes the armour obliquely. The resistance offered by the hard steel face seems to be such that shot striking it at an angle of more than 20° from the perpendicular to the face make but a moderate indentation and are broken up.

'Coal' armour.

Attempts have been made to ascertain to what extent the coal carried by unarmoured merchant vessels could be used for their protection, if they were brought into the service in time of war.

Some experiments were carried out at Portsmouth in December 1878, when the 'Oberon' was fitted so as to contain a thickness of from eight to ten feet of coal, within which were introduced two ⅝-inch boiler-plates. This was fired at with a 7-inch naval gun of 90 cwt. The projectile weighed about 115 lbs., and with a velocity not exceeding 1,400 feet a second, it was capable of penetrating eight inches of iron, and yet it failed to penetrate the ten feet of coal with the ⅝ inch of boiler plate. A shell was also fired with a reduced charge of 2½ lbs., but it neither set the coal on fire nor did any real damage to the ship. A double shell, containing a bursting charge of 13 lbs., was also fired, which likewise failed to set the coal on fire.

Effects of shot on armour in actual war.

Experimental practice against armour is necessarily conducted under conditions most favourable to the guns and least favourable to the plates. Every precaution is taken that the target be hit fair at distances carefully and accurately measured. In action this, of course, could only be brought about by a combination of circumstances which would amount to a lucky accident. It is therefore important to note the few recorded instances of the perforation or serious injury of protecting plates by hostile shot, in order that some idea may be formed of the behaviour of guns and armour in real warfare.

An interesting account of the effect of shot on the armour of a broadside ship has been given by Captain George Belknap, of the United States Navy, in a paper entitled 'Reminiscent of the new "Ironsides," off Charleston,' in the American quarterly review, *United Service.* He says, 'She did not get in close enough to the hostile batteries to receive any damaging blows, but three of her port shutters were knocked off, and some of the hits showed as crushing effects on the armour as were ever given her in any subsequent action in which she took part. The sound of the heaviest projectiles striking the armour was scarcely perceptible inside the casemate, but the clang of the port shutters when struck was like a clap of thunder.' In the frequent engagements with the Confederate batteries, in which she afterwards took part, the 'Ironsides' was repeatedly struck. On one occasion, when 'within nine hundred yards of the enemy, she received thirty-one hits.' The shot were mostly 10-inch smooth-bore, but a certain number were rifle projectiles. 'The round shot,' says Captain Belknap, 'always made the most impression on the armour; the bolts (elongated projectiles from the rifled guns) rarely struck fairly end on but generally sideways, and their supposed punching power never had verification in the experience of the "Ironsides."' To protect the deck from plunging

fire, sand-bags had been laid on it; the effect of the shot striking the deck thus protected 'was to scoop off the sand-bag—the shot bounding overboard—and shatter the inch iron plate under the planking, leaving the deck itself almost unscarred.' On one occasion the ship was struck seventy-four times, and received no other harm than the loss of one or two port shutters.

Señor Heriz[1] tells us that 'the city of Callao was bombarded on May 2, 1866, by the Spanish ships "Numancia," "Almansa," "Blanca," "Berenguela," "Resolucion," and "Villa de Madrid," with the corvette "Vencedora"; the first of the above vessels only being armoured. Amongst the guns of the Peruvians there were eight rifled Blakely 500-pdrs., and six Armstrong 300-pdrs., four of the former being mounted in two fixed plated turrets.' The Peruvians had also two turret-vessels of the 'Monitor' type, with two guns each, 100-pdrs. and 150-pdrs. 'A solid 300-lb. projectile penetrated the armourclad "Numancia" at the water-line—the ship being 1,640 yards off—to a depth of ten inches, passing through the armour,' which was of five inches in the thickest part, 'doubling up the frames and loosening the bolts.'

The two naval engagements in which the 'Huascar' took part are interesting enough to deserve special notice. Not only were they fought by armourclads of the modern, if not of the most recent type, but the guns with which the armour-plating was attacked were rifled pieces, firing Palliser projectiles, and of the British pattern. It will not be necessary to recount the political circumstances which preceded the action between H.M.S. 'Shah' and 'Amethyst,' and the Peruvian turret-ship 'Huascar,' but simply to describe the features of that contest as bearing upon the behaviour of plated structures when exposed to the fire of heavy rifled guns. Descriptions of the several ships will be found in other parts of this work,[2] and it will be enough to give here the following short summary of their main features. The 'Shah' is an iron-hulled, unarmoured frigate, 'Shah' and 'Huascar.'
cased with wood, with a displacement of 6,040 tons. At her official trial in April 1876 the indicated horse-power was 7,350; and the total of the runs then made showed a mean speed of 16·4 knots an hour. Her armament in 1877 was composed of two 9-inch 12-ton guns, sixteen 7-inch $6\frac{1}{2}$-ton guns, and eight 64-pdrs., all rifled muzzle-loaders, the last-named not firing battering projectiles. The 'Amethyst' is an unarmoured corvette of the modern type, with a

[1] *Memoria sobre los barcos acorazados*, p. 51.

[2] See for 'Huascar,' Part I. chap. ix.; for 'Shah,' chap. xvii.; and for 'Amethyst,' chap. xvii.

displacement of 1,934 tons, of 2,144 indicated horse-power, and carrying fourteen 64-pdr. guns. The complement of the 'Shah' was 602, that of the 'Amethyst' 226 officers and men. The 'Huascar' is an iron-hulled, armourclad turret-vessel of 1,101 tons,[1] and 1,500 indicated horse-power; at the time of the action she is said to have had new boilers, and to have been able to steam 11 knots easily. Her plating on the hull is four inches thick, tapering to 2½ inches at the bow and stern. The turret-plating is 5½ inches in thickness. She carried two 10-inch 12-ton rifled muzzle-loading 300-pdrs. on Sir W. Armstrong's system, in a single turret, and two 40-pdr. muzzle-loaders, also rifled, on the quarter-deck. The two British ships having sighted the armourclad gave chase, got up steam for full speed, and prepared for action. The 'Huascar' tried to escape towards the land, but the 'Amethyst' being in shore assisted to confuse her movements. She then stopped, and an officer was sent on board her by the British Admiral, with a demand to haul down her colours, which was not complied with. The action began at 3.6 P.M. The 'Shah's' firing was telling and well-sustained; but the 'Huascar' being only three feet out of water and frequently end on, was a most difficult object to hit. The 'Shah's' guns were also frequently silenced by the Admiral's order when, owing to the 'Huascar' placing herself close under the town of Ylo, there was a risk of injuring the town. The firing was also stopped for a little while in consequence of the 'Huascar's' colours coming down. The halyards had been shot away; and the colours were soon rehoisted. The 'Amethyst's' fire was conducted with great precision; but the armament of 64-pdrs. was useless except to distract attention and draw the 'Huascar's' fire occasionally off the 'Shah.'

The 'Huascar' replied with shell from her turret guns, and continued manœuvring backwards and forwards in front of Ylo, her draught of water being 14 feet and that of the 'Shah' 27 feet. The navigation was rendered highly dangerous owing to the rocks and shoals at the entrance to the bay. The 'Shah's' distance from the enemy was, consequently, principally from 1,500 to 2,500 yards. The engagement was partly a following and partly a revolving one, with occasional attempts on the part of the 'Huascar' to ram, which had to be carefully guarded against with a ship so long in proportion to her beam, and therefore so slow in turning as the 'Shah.' Owing to the size and weight of the latter ship and the confined space to manœuvre in, she was unable to benefit by steaming up to an effective range of 1,000 or 1,200 yards and stopping to deliver a steady fire;

[1] 2,100 tons displacement, according to the *Revue Maritime*.

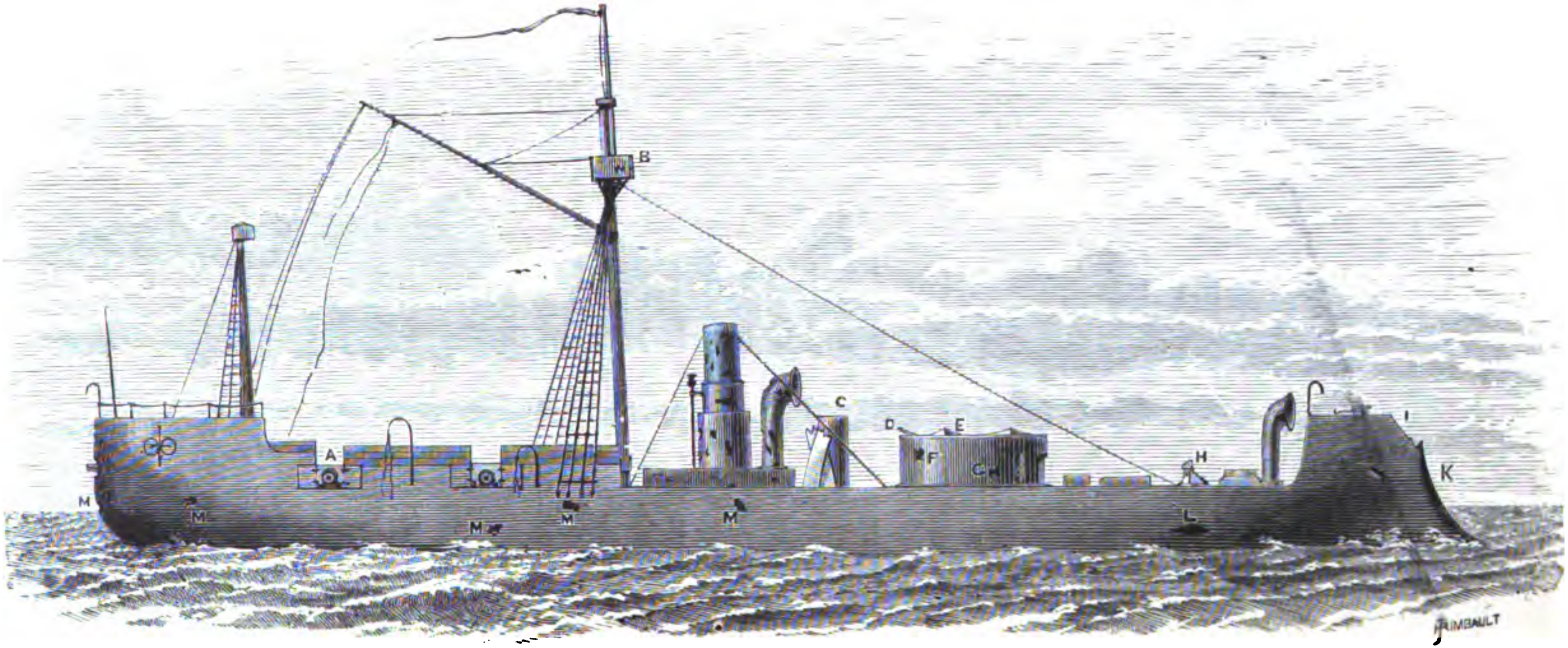
the greater rapidity of the Peruvian's movements rendering such a proceeding dangerous, and the risk of being rammed before being able to 'gather way' again being too great. The 'Huascar' appeared to steam about 11 knots, and always contrived to keep her turret guns pointing at her opponents except when in their loading position. About 5 P.M., the turret-ship being clear of the shoals, advantage was taken of the opportunity to close. The 'Shah's' Gatling gun was then fired from the foretop. It was at this moment that the Whitehead torpedo was launched at the turret-ship, as related in the chapter on torpedoes (Part II. Chap. iii.). The action ceased at 5.45 P.M. No damage was done to either of the British ships beyond the cutting of a few ropes. The Peruvian had one man killed and three wounded.

On a subsequent inspection, according to the approximate calculations of two British officers who visited the vessel, from seventy to eighty projectiles must have struck the 'Huascar,' principally about the upper deck, funnel-casing, bridge, masts, and boats. Numbers of pieces of shell were sticking in the woodwork. One 9-inch *common* shell struck the hull on the starboard side, about two feet from the water-line and 50 feet from the stern, in the foremost ward-room cabin. It burst in the backing, the head splintered in all directions, and the base continued its course till brought up against the inner skin on the opposite side. Don Manual Carrasco, in an official report, states that the explosion of this shell killed one seaman and wounded one officer and two men. The plating at the spot where it entered was about 3½ inches thick. Two 64-pdr. shells left indentations on the plating. One heavy shot, evidently a ricochet, hit the upper edge on the starboard side, scoring it to a depth of three inches after going through the bulwark. Another hit the plating two feet from the water-line at an angle, making a dent two inches in depth and 18 inches in length. On the port side there was a shot similar to the ricochet. The hull showed that several 64-pdrs. had struck it, only leaving a mark. One shot struck the poop on the port quarter and went out on the starboard side, splintering an iron beam. The funnel-casing and funnel had been hit about twelve times by shot and pierced by the Gatling gun. The turret had only been struck once by a 7-inch projectile, hitting direct and penetrating three inches.

Capture of the 'Huascar' by the Chilians.

The battle which resulted in the capture of the 'Huascar' by a Chilian squadron, comprising two armourclads of recent design, conveys more exact information as to the effect of fire upon an armoured ship than that just described. The 'Huascar,' accompanied by the unarmoured corvette 'Union,' under Admiral Grau, of the Peruvian

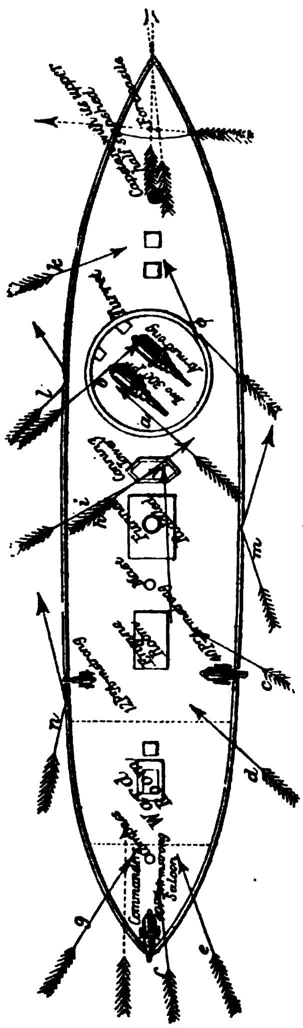
Figs. 22 and 23.



THE 'HUASCAR' (AFTER CAPTURE).

A. Quarter-deck gun. B. Screen round Gatling gun. C. Conning-tower. D, E. Injured roof of turret. F, G. Shots striking turret. H. Capstan. K. Stem. L. Shot through from port side. M. Shots striking starboard side.

Navy, was returning to the northward from a cruise along the Chilian coast when, about half-past three on the morning of October 8, 1879, she was sighted by a division of the Chilian squadron under Admiral Rivero. The Chilian flag-ship was the armourclad 'Blanco Encalada,' and the two wooden unarmoured cruisers, the 'Covadonga' and the 'Matias Cousino,' were in company. It may here be proper to mention that the 'Blanco Encalada' and the 'Almirante Cochrane,' which subsequently took a decisive part in the action, are sister ships, and are described in Part I. Chapter xi. of this work. Their displacement is about 3,480 tons, they each carry six 9-inch 12-ton muzzle-loading Armstrong guns, have 9-inch armour on the sides, tapering to $4\frac{1}{2}$ inches at the ends, and 8-inch armour in the central battery, in which their guns are mounted. Their highest speed should be about 13 knots.



PLAN OF THE 'HUASCAR' (SHOWING HITS BY SHOT).
(*l, m, n, o,* glancing shots.)

We now return to the more important incidents in the engagement. The Peruvian ships tried to escape to the northward, but their retreat was cut off by the appearance ahead of them of the second Chilian division with the 'Almirante Cochrane.' At 8.40 A.M. this ship was about 3,000 yards from the 'Huascar,' which at 9.15 fired her first shot at the 'Almirante Cochrane.' The latter did not reply, but continued to approach till her fire might be more effective; and a few minutes later a well-sustained fire began from both ships. The 'Blanco Encalada' meanwhile neared the Peruvian, and drew off a part of the fire which had previously been concentrated on the 'Cochrane.'

As the fight went on, the vessels drew close together, and a gallant attempt was made by the Peruvian to dispose of his assailants with the ram. At one time the 'Huascar' passed the 'Blanco' at a

distance of only about 25 yards, firing her guns and keeping up a warm discharge from the machine guns in her top. The Peruvian was eventually placed between two fires by the Chilian armourclads and was obliged to submit. The 'Covadonga' fired one shot at the close. The engagement lasted precisely one hour and a half, the 'Cochrane' being under fire the whole time, and the 'Blanco' only during the last fifty minutes. The 'Huascar' had a complement of 200 officers and men. Admiral Grau and 38 officers and men were killed; and among the 162 prisoners 30 were wounded. The losses in the Chilian squadron were confined to the 'Cochrane,' which had twelve men wounded, one mortally. The other ships escaped without a single casualty. The 'Huascar' had been greatly injured by the fire of her opponents. The subjoined drawings give a general idea of her appearance after the battle, and of the state of the conning tower in which Admiral Grau was killed. (See figs. 22 and 23.)

The Peruvian vessel was struck upwards of twenty times, and received more than a dozen severe blows. Mr. H. D. Pender, in a letter to the *United Service Gazette*, describes the effect of each important hit. Numbering the shots consecutively in the order in which they appeared to him on going round the ship, he gives the following information:—

No. 1. Starboard side. Struck the upper edge of the plating abreast the fore part of the turret, forcing up the deck-covering plate.

No. 2. Penetrated the armour 18 inches above the water-line and over the engine-room, passing through the starboard waist cabins, over the engine-room platform, and bursting in the port cabins.

No. 3. Penetrated just above the water-line, almost abreast of the stern-post, and burst in the ward-room.

No. 4. Entered the after cabin, carrying away two beams and the sheave of the relieving tackle, and killing all the men steering.

No. 5. This was a fore-and-aft shot. It struck the stern under the upper deck, smashing the stern-post, carrying away bulkheads, and killing all the men at the tiller.

No. 6. Entered on the port side, opposite No. 4 shot, two feet above water, bursting inside the pantry.

No. 7. Struck the edge of the upper deck abreast the after part of the turret. The turret has a deep egg-shaped splash on it, probably from this shot.

No. 8. Penetrated between the turret and the forecastle, 2 ft. 6 in. above the water, and burst in the carpenter's cabin.

No. 9. This was an end-on shot fair on the cutwater at the deck line. It deflected upwards, carrying away bitts, etc.

Two shots struck the turret, viz.:

No. 10, which, looking at the turret from outside, but a little to the left of the right-hand gun-port, level with the trunnions, penetrated the turret between two plates right on the joint, hit the right trunnion of the right, and carried away the cap-square, compressor, etc. The gun was not injured, but its crew were all killed.

No. 11 struck the turret near the top at right angles to the path of No. 10. It appeared to have exploded in the turret, as the webs of two of the transverse beams were cut away, leaving the flange, and the beams were not deep enough to admit of a whole shell passing through them. The upper part of the breech of the left gun was much scored; the carriage was intact. Some fragments of this shell passed out again at the upper edge of the turret, killing the officer second in command of the ship.

Nos. 12, 13 and 14 struck and destroyed the hexagonal thinly armoured conning-tower; and one killed Admiral Grau.

'On the main deck,' says Mr. Pender, 'the ward-room and stern cabin were quite destroyed; there was hardly a trace of the bulkhead; the contents of the state-rooms were strewn about the flooring, and the upper deck ceiling was one mass of powder [1] and disintegrated human remains.' The engines and boilers, and the turret-winches were untouched.

[1] Probably marks of explosion.

CHAPTER II.

GUNS AND GUNNERY.[1]

Annual cost of naval guns.

THE gunnery question has assumed very grave importance in connection with our naval administration. The cost of the guns for the navy represents a large sum annually. In 1877–78 the expenditure was not less than 371,865*l.*; and while this amount was expended in a single year at the Royal Arsenal at Woolwich, it is somewhat discouraging to observe that all the improvements recently introduced into ordnance are due to the inventive skill of private manufacturers.

Progressive state of gunnery.

The progress of the art of gunnery at the present day, and the remarkable advance which has been made, even within a very recent period, render it extremely difficult to give a minutely accurate account of the armament of the principal navies of the world. In the British service, not only have guns of greater weight and increased proportional length been adopted, but the efficiency of those in use has been shown to be capable of augmentation by 'chambering,' that is, enlarging the receptacle for the cartridge in the inner portion of the bore. In France the system of constructing heavy ordnance for the sea-service has undergone several modifications. As far back

[1] LIST OF AUTHORITIES.—*Treatise on the Construction of Ordnance in the British Service* (Official). London, 1877. The same, 1879. *Treatise on Ammunition* (Official). London, 1877. *Short Notes on Gunpowder and its Manufacture.* By Major W. Wardell. Woolwich, 1877. *Cast Steel Factory of Fried. Krupp, near Essen.* London, 1879. *Renseignements sur l'Artillerie de la Marine de l'Italie.* Par M. H. de Poyen. Paris, 1878. *Description sommaire des bouches à feu de la Marine des États-Unis.* Paris, 1875. *Description sommaire des bouches à feu de la Marine russe.* Paris, 1877. *Manuel d'Artillerie à l'usage des Officiers.* Par H. le Bazic, Lieut. de Vaisseau. Paris, 1880. *Conversions of Cannon.* By Commodore E. Simpson, U.S.N. *United Service,* vol. i. 1879. *Navies of the World.* By Lieut. Edward W. Very, U.S.N. London, 1880. *The War Ships and Navies of the World.* By Chief Engineer J. W. King, U.S.N. Boston, 1880. *Times, Engineer, Engineering, Iron, Revue Maritime, Mittheilungen aus dem Gebiete des Seewesens, New York Army and Navy Journal,* etc.

as 1871 'chambering' to a certain extent was formally adopted for naval guns of large size; and the command over the working of steel which the progress of science has placed in the hands of the metallurgist has been taken advantage of in the production of the newer guns for ships. In Germany the well-known Krupp guns of the higher calibres are now manufactured on a system which differs from that originally employed. The Austrians are engaged in carrying out experiments with the hardened bronze proposed by General Uchatius, with the object of extending its use to pieces of considerable size. In the Italian navy are to be found the heaviest and most powerful weapons yet produced. In the United States the necessity of arming ships-of-war with rifled guns of great range, accuracy, and penetrative power has now been fully recognised, and the old cast-iron smooth-bore is being converted into a breech-loading rifle on the system of Sir William Palliser. In Russia, though the smooth-bore still figures as the weapon carried by some of the older turret-vessels, it is being replaced; and the Obukoff Works have long been employed in turning out guns similar in most respects to those of Krupp, in the construction of which recent improvements have been adopted. Our own Government has ordered the manufacture of heavy breech-loaders for large armoured ships, which are to be substituted for less powerful pieces loading at the muzzle, and it is causing experiments to be carried out with guns manufactured by Sir William Armstrong and Co., the performances of which surpass considerably those of ordnance of similar weight already in the service.

Armament of the British navy supplied through the Military Department.

The British navy is supplied with its armament on a plan differing from that employed by any other of the important maritime States. In all the foreign services the weapons required for the sea-service are either manufactured by a particular department of the naval administration, or are purchased from private firms by it. In France, Russia, and the United States the navy has its own ordnance establishments, and in the former country its own gun and other factories. In Germany, Austria, and Italy ship-guns are ordered from the great firms of Krupp or Armstrong. In England, on the other hand, no department of the Admiralty is concerned with the production of guns or any other of the warlike stores supplied to the ships of the fleet; all are manufactured by a military department under the supervision of officers of the army. Even the sums required to provide them are voted in the annual Army Estimates, and not in the Estimates for the Navy; and when the Admiralty has occasion to resort to private makers for a particular piece of ordnance, or a

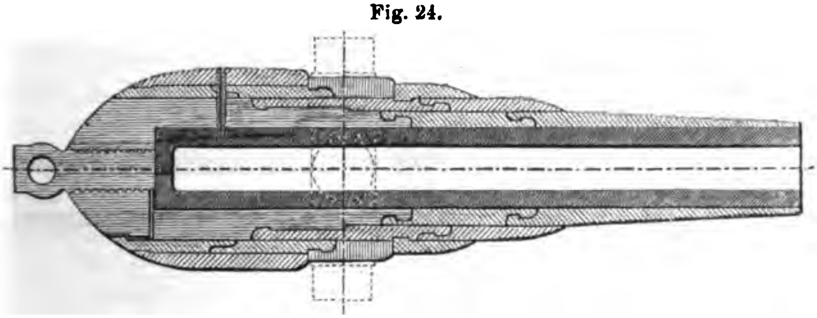
particular fitting or appliance connected with the armament of a ship, it has to do so through the intervention of the War Office, which becomes the actual purchaser and final custodian of the articles supplied by the manufacturer. This practice is in reality of not very long standing, being, in fact, unknown before the Crimean war. An important administrative change was made about five-and-twenty years ago. The Board of Ordnance—a department independent of, but having intimate relations with, both the Admiralty and the War Department—which had for centuries supplied both services with the weapons used by them, was merged in the Military Department, which took over at the same time the business of providing the Navy with its armament. The sea-service then ceased to have the same direct participation in the provision of its war *matériel* that it had formerly possessed; and no longer continued to be represented in the reconstituted manufacturing departments as it had been on the Board of Ordnance.

Woolwich guns. The guns now mounted on board British ships are—with the exception of a few light pieces in some of the smaller vessels, and in particular positions in armourclads—rifled muzzle-loaders, either specially manufactured or converted from the old smooth-bores. All the former are built up in a similar manner. Over an inner barrel of steel, technically known as the A tube, a certain number of coils, or other pieces of wrought-iron, according to the size of the gun, are shrunk on, a cascable being screwed into the end of the coil which comes over the rear extremity of the tube, against which it fits closely. The official *Treatise on the Construction of Ordnance* describes the process of manufacturing the Service 7-inch 6½-ton gun, which may be taken as the type and representative of the existing mode of construction. The steel for the inner tube is supplied to the Royal Gun Factories at Woolwich Arsenal by the private trade in the form of a solid ingot. It is rough-turned and bored, then heated in a vertical furnace, and tempered in an oil bath to increase its toughness. After this operation it is again turned, and bored, and tested by hydraulic pressure. The B tube, of wrought-iron, which comes next outside the steel, is formed of two single coils united together. The interior having been fine-bored, it is gauged at intervals of twelve inches down the bore, and the A tube is turned down accurately to fit it. The breech-coil is formed of a triple coil,[1]

[1] *Treatise on Construction of Ordnance*, ed. 1877, p. 172. The edition of 1879 (p. 166) has 'single coil.' In the latter the mode of manufacturing the particular gun (7-inch) is probably meant; in the former the general mode is apparently described.

a trunnion-ring, and a double coil welded together. The former is made by coiling three bars one over the other and welding them, and this when cold has a shoulder ten inches long formed upon it for the trunnion-ring. This is made of iron slabs welded together and forged into a ring. When the three parts of the breech-coil are completed, the trunnion-ring is heated and dropped upon the shoulder of the triple coil, which is placed upright to receive it. Before the ring has cooled the double coil is put in its place. The whole mass is consolidated beneath a hammer; and a cast-iron mandril, somewhat larger than the bore, is forced into the jacket so as to bring all the parts into absolute connection. The breech-coil is then bored and turned, and the trunnion-ring placed and shaped. The cascable screw thread is cut in the breech end of the jacket. When the various parts are completed, the B tube is heated over a wood fire until it has expanded sufficiently to drop over the A tube.

Fig. 24.

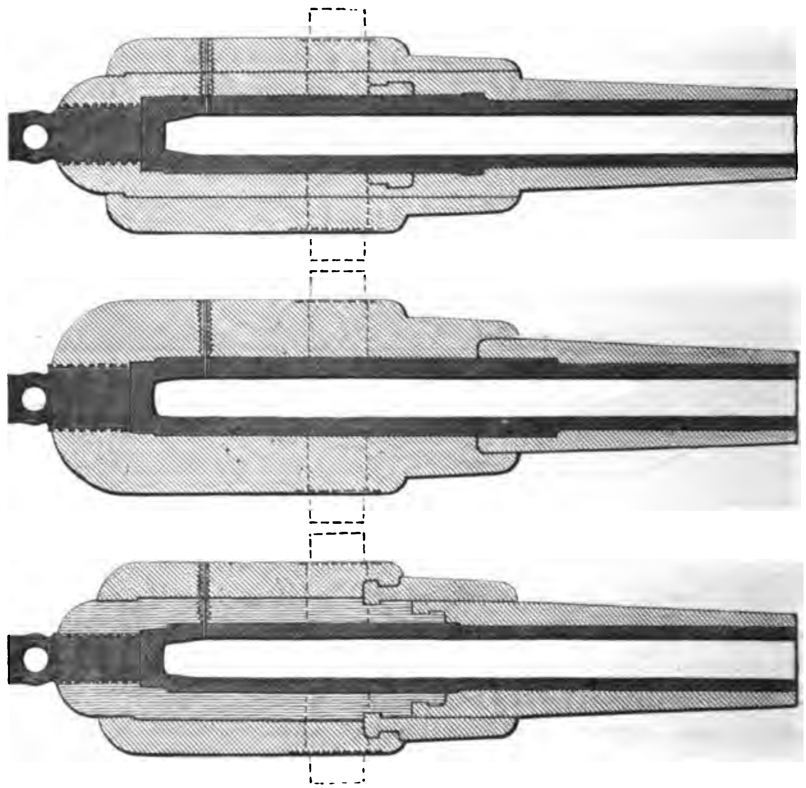


9-IN. WOOLWICH GUN (ARMSTRONG, OR ORIGINAL, CONSTRUCTION).

The Service, or the so-called Woolwich gun, with which the ships of the Royal Navy are now armed, is due to the invention of Mr. Fraser. The following account is taken from a paper by Commodore Simpson:—'Mr. Fraser's attention was early drawn to the labour and expense of turning many surfaces, and the frequent moving of heavy masses. He conceived the idea of making the coils thicker, thus reducing their number, and of welding them together, instead of shrinking them the one over the other; also of placing them the one before the other, united by end-welding, instead of shrinking them the one over the other, breaking joint, as in the original construction. He thus delayed the time of shrinking the reinforce on to the inner tube, until the mass had reached a large size. He considered that the frequent forgings under the hammer would improve the condition of his iron, and that the expense and delay of moving heavy masses so frequently would be avoided; be- Commodore Simpson, U.S.N. on the Fraser gun.

sides, the more frequent forgings would enable him to use a cheaper iron for his coils. His system of welding coils together involved not only the union of coil over coil, but also the welding of them together endwise, and in this he recognised a means of increasing the resistance that the reinforcing coils could offer to longitudinal strain. The advantage gained in this direction was so great as to enable him to suppress altogether the "breech-piece," so that in his present construction the coils are in immediate contact with the inner tube, the

Figs. 25, 26, and 27.



9-IN. WOOLWICH GUNS (FRASER CONSTRUCTION).

resistance to longitudinal strain given by the end-welding of the separate coils being assisted by the welding of coil with coil. Mr. Fraser's improvement on the original construction has been recognised and adopted by the English Government, which now reaps the benefit of it by being enabled to manufacture its guns at one-third less expense than under the Armstrong system.

'In the foregoing it will be seen that Mr. Fraser, like Sir William

Armstrong, rests his claim for safety in the wrought iron, and that he alludes to the steel tube as an element of weakness which is necessarily present, but to guard against which his large coils are claimed to be a security. Yet Mr. Fraser has no idea of abandoning the steel tube; he considers it necessary in order to supply "hardness and clearness of bore," as does Sir William Armstrong; and he thus supplies his testimony to the conclusion inferred from Sir William Armstrong's statement, before cited, that it is impossible, or at least injudicious, to construct a gun wholly of wrought-iron. Even if the claim of safety be conceded, yet the presence of this element of weakness has operated much to influence the endurance of the Woolwich gun. Comparison of the Fraser and Armstrong systems by Commodore Simpson, U.S.N.

'In the study of the Woolwich gun, even conceding safety, we find the splitting of the steel tube as an acknowledged weakness. This shows that some radical defect exists in the construction, which stamps it as at least imperfect. The defect exists in the want of homogeneity in the wall of the piece.

'But, in however small a degree the steel may be introduced, its presence destroys the homogeneous character of the structure. This is apparent when we consider the elastic property of the steel, and the absence of that property in the wrought iron.

'In what has been said thus far, the claim of safety in the Woolwich gun has not been disputed. It has been conceded for the sake of argument, and because no instance could be cited where an explosive burst had taken place after a gun had been put in service. A claim of safety may be made early in the use of any gun, but it can only be allowed unqualifiedly after a long period of trial and actual experience in service, where the conditions favouring the piece may not always be so advantageous as on a practice-ground, where all manipulations are performed by experts.

'The bursting of a Woolwich 38-ton 12-inch gun while at target-practice is the most startling occurrence that has agitated the artillery world for many years; in fact, since the introduction of the new constructions. Remarks of Commodore Simpson, U.S.N., on the bursting of the 'Thunderer' gun.

'Mr. Fraser does not seem to have contemplated such a catastrophe as the transverse rupture of the gun which took place in the turret of the "Thunderer."

'It is evident that the steel tube was unable to resist the longitudinal strain that was brought to bear upon it, and that the welding of the surrounding wrought-iron tube was not sufficiently complete to prevent the strain from tearing the coil asunder.

'We conclude this portion of our subject with the remark that,

for a nation that is content with a muzzle-loading gun, the experience with the Woolwich gun is satisfactory up to the 10-inch 18-ton gun, in which all the good points found in those of a lesser weight and calibre seem to be concentrated; but that, in advancing beyond the size of this gun, the Woolwich people have found themselves beset with difficulties which have overtasked even their powers to surmount, and which have led them into the position of throwing doubt on their whole system of construction.'

Woolwich rifling.

Lighter guns, such as the 7-pounder and the 9-pounder boat-guns, are made either wholly of steel, or chiefly of steel with a jacket of wrought iron covering a portion of their exterior. The Woolwich system of rifling may be described as consisting of a small number of broad, shallow grooves, into which studs of bronze fixed in the projectile fit, and so rotate the latter on being fired. In all guns larger than the 7-inch the twist of the rifling is increasing; in most of the smaller ones it is uniform. This system has been abandoned in some of the newer pieces; the 80-ton gun, for instance, being rifled on the polygroove plan; that is, having a large number of grooves of moderate width. Where the latter system has been adopted the studs have been dispensed with, and the projectile is rotated by a 'gas-check,' or saucer of copper attached to its base, which fills up the grooves and prevents the erosion of the bore by the escape of gas over a shot lying in it, and also imparts rotation to the shot. This rotating gas-check is the invention of the Elswick Company.

Guns used in British navy.

The following list shows the natures of heavy guns used in the British sea-service:—

16-inch of 80 tons	11-inch of 25 tons
12½ " 38 "	10 " 18 "
12 " 35 "	8 " 9 "
12 " 25 "	7 " 6½ "

There is also a light gun carried by some of the smaller vessels with a 7-inch bore weighing 90 cwt., which is made in a similar manner to that already described. The unarmoured vessels are largely armed with 64-pounders.

Palliser converted guns.

Many guns of the same calibre as the 64-pounders, and using the same projectile, have been converted from old cast-iron smooth-bores on the plan of Sir William Palliser. With his mode of conversion a cast-iron gun is bored out, and a wrought-iron tube, slightly smaller in exterior diameter than the enlarged bore, is made to fit into this casing. After proof the barrel inserted is permanently expanded and fits tight against the interior of the cast iron. It is there secured by a collar screwed into the muzzle and a wrought-iron plug inserted

from underneath. The tube is made of coils, and its inner end is closed by a wrought-iron cup. The breech portion of this tube is reduced by turning for a certain length, and a second tube, consisting of two coils united, is shrunk on. This plan has proved very successful for guns of moderate power, and a large number of old cast-iron pieces, which would have been useless in their original shape, have been rendered serviceable by adopting it.

Rounds fired from British guns.

Accounts have been occasionally published of the endurance of British Service ordnance, as shown by the number of rounds fired from pieces of different natures. From one of these the following information has been taken. At the time of its publication the greatest number of rounds fired from the 12-inch 35-ton gun was 152, with powder-charges ranging from 90 lbs. to 115 lbs. of pebble or P. powder, and projectiles varying in weight from 600 lbs. to 700 lbs. The maximum elevation given was 10°. With 110 lbs. of powder a range of 4,500 yards was obtained; with 115 lbs. of powder the range was increased to 4,800 yards. The penetrating power of the gun was considered equal to the perforation of 14 inches of armour upon the 'Warrior' backing at a distance of 500 yards. From the 25-ton gun 460 rounds had been fired, the charges being increased from 50 lbs. to 85 lbs. With 9° elevation the highest recorded range was 3,761 yards. At 500 yards a 12-inch armour-plate on the same backing as that just mentioned could be perforated. The 10-inch 18-ton gun had been fired 720 times with a projectile of 400 lbs. weight; it could penetrate an 11-inch armour-plate on the 'Warrior' backing at 500 yards. Not less than 1,222 rounds have been fired from one of the 9-inch 12-ton guns, the charge of powder being sometimes as high as 60 lbs. With a battering charge of 43 lbs. a range of 9,920 yards was obtained. With 50 lbs. of powder eight inches of armour on the 'Warrior' backing could be perforated. At 200 yards the 8-inch gun of nine tons was considered equal to the perforation of a 7-inch plate. From one of the converted 64-pounders, on Sir William Palliser's system, 2,285 rounds had been fired, leaving the piece in a serviceable condition. These results have been, or at all events may now be, surpassed, in consequence of improvements in the quality of the gunpowder used for the charges of heavy guns and from other causes. They are given here as showing what our service guns have proved themselves capable of doing, under conditions less favourable than those which at present exist. The 12½-inch 38-ton gun has proved itself capable of penetrating 18¾ inches of iron at 500 yards and 17¾ inches at 1,000 yards. With respect to cost, the following is an extract from a table published officially:—

Cost of guns.

	£	s.	d.
12-inch 35-ton gun	2,153	13	9
12 „ 25 „	1,715	13	5
10 „ 18 „	1,005	10	2
9 „ 12 „	739	17	8
8 „ 9 „	567	12	10
7 „ 6½ „	424	11	10
Converted 64-pounders, 71 cwt. . .	79	18	6
„ „ 58 „ . .	87	13	2

In all cases the latest pattern or 'mark,' as it is termed, has been taken. The above prices are probably merely for the guns as they leave the factory, and no portion of the expense of testing them, nor firing them for range, accuracy, or endurance, seems to be charged in the table given.

Projectiles of the Woolwich guns.

The projectiles used in the navy for the Woolwich guns are shell of different kinds and case-shot. The former class is subdivided into several sections, as common shell, double shell, Shrapnel shell, and Palliser shell.[1] Common shells are usually about three calibres in length—in some cases they are much shorter—and are intended to be completely filled with powder as a bursting charge. Their walls are thin, and it is believed that they would be most effective when used against unarmoured ships. The double shell is used with the 7-inch 6½-ton gun only amongst naval heavy ordnance. It is about four calibres long, and it is chiefly intended for use against wooden ships at moderate ranges. It has given good results during practice, when fired up to 2,000 yards. The Shrapnel shell, externally, resembles the common shell to some extent. Its walls are weakened by longitudinal grooves inside to assist its breaking up on bursting. At the base there is a chamber for the powder, into which a tin cup fits. Above the latter is an iron disc, having a slender iron pipe screwed into it. Through this pipe the bursting charge is introduced into the chamber at the base, and the fuse socket is screwed into its upper portion. The interior is filled with sand shot, i.e., iron shot cast in sand, weighing 2 ozs. and 4 ozs., kept in place by resin poured in hot. The head is made of Bessemer steel, lined with wood. When acting, the fuse ignites the powder in the chamber through the iron pipe. The head of the shell points during its flight towards the object fired at, so that the bursting charge is in the rear of the iron balls, all of which are driven forward on explosion. Shrapnel is considered to be most useful against boats, or men not protected by cover, at ranges beyond those at which case-shot is effective.

[1] The Palliser *shot*—supplied for certain guns—is in reality a *shell*, with a reduced interior cavity, and without a bursting charge.

The battering projectile of our naval guns for use against armoured ships is the invention of Sir William Palliser, who has done so much for the armament of our ships, and whose name this projectile bears. In 1863 he proposed a projectile of iron cast in a metal mould called a 'chill,' to render it hard for the penetration of iron armour, providing against the effect of brittleness by the form of head, which was an 'elongated point.' In those now manufactured the heads are cast in metal and the bodies in sand. The length of those in the service varies from a little over two calibres to a little over two and a half. In the centre of the bottom is a filling hole 'bushed' with cast-iron, and closed with a gun-metal screw plug. These shells have no fuses, as they explode on violent impact against armour. The cause is supposed to be that, on the gun being fired, the powder in the shell is set hard back against the base of the cavity in which it is contained, forming a dense mass so hard that sometimes it cannot be cut by a copper tool. When the shell strikes an armour-plate, this hard mass is believed to be dashed forward, and pressed into the contracted part of the shell, undergoing great friction, which should suffice to cause explosion.

There are practically two classes of case-shot in the service, those for guns larger than 7-inch being made on a somewhat different principle from those for the smaller guns. The case is made of tin, with an iron disc at the bottom, and is filled with shot weighing 8 ozs. It carries close, and can be used against boats, or bodies of men uncovered, up to 600 yards.

Gunpowder in the British service.

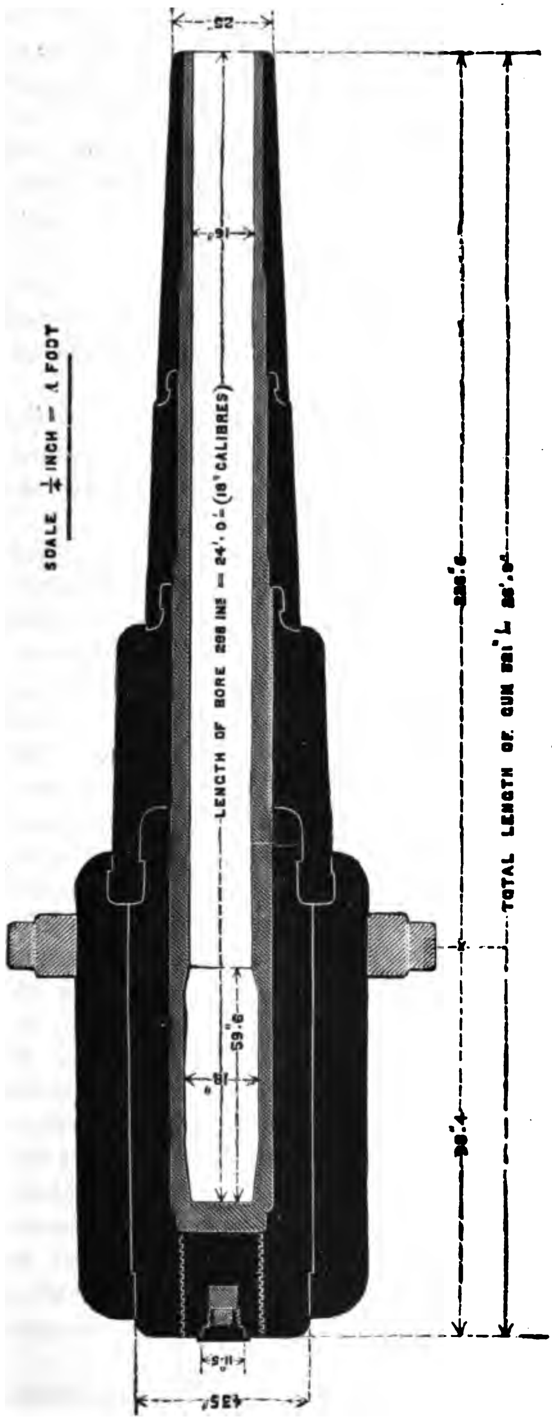
Of late years much attention has been paid to the action of gunpowder when fired, especially in guns of the heavier natures, and it is doubtful if the best form of it has yet been hit upon. Experiments, with the object of deciding which kind is most suitable to our newer heavy guns, are being actually carried out. On the introduction of rifled ordnance it was considered advisable to use a powder which would burn more gradually when ignited, and would strain the gun less than that employed for smooth-bores. The density and size of the grains were accordingly increased. Rifled large grain, or, as it is called, 'R.L.G.,' with grains measuring from one-eighth to a quarter of an inch across, was tried and found to answer well with guns of small calibre. When guns of 7-inch bore and upwards were introduced, as their cartridges required large quantities of powder, it was found desirable to use a still more slowly burning explosive. This led to the manufacture of pebble, or P. powder, of high density and much larger grain. This P. powder is made in the form of cubes, with sides of about five-eighths of an inch. As the size of the guns

and charges increased, an advance was made to cubical, or P^2 powder, the grains of which are approximately cubical in form, with rounded edges, the length of each edge being about an inch and a half. It has been used with the 35-ton and 38-ton, and will probably be used with all guns heavier than the 8-inch gun of 9 tons. The superiority of the German prismatic powder, pressed into separate hexagonal blocks, seems likely to lead to its introduction into our own service.

80-ton guns. A remarkable feature of gun-construction of late years has been the manufacture of pieces of enormous size. In this country, and very recently in Italy, guns of a weight which a few years ago would have seemed impossible have been made. In 1873 the Russians were at work upon the 'Peter the Great,' which was to have twenty inches of armour, and two Italian ships were to have plating of at least the same thickness. We had no guns capable of piercing such a mass of metal, and the Director of Naval Ordnance applied to the War Office authorities for a gun capable of sending a projectile through twenty inches of iron at 1,000 yards' distance. The Admiralty, at the same time, proposed a design for a turret-ship capable of carrying four such guns. It was decided that an experimental gun should be manufactured to weigh about 75 tons, the cost being estimated at about 8,000*l.* The weight was finally settled at 80 tons. This gun was manufactured on the Fraser system in the usual manner, having a steel tube and a few heavy coils.

It was completed in September, 1875. The subsequent modifications in this gun will show how much the ideas of its constructors have advanced in the meantime, and how many features in the ordnance turned out by other makers, both in England and abroad, have been adopted at Woolwich. The calibre was at first 14½ inches, and it was rifled with eleven grooves. The gun was afterwards bored up to sixteen inches, and, with a projectile weighing 1,700 lbs., was capable of piercing 21 inches of iron at 1,000 yards' range; the charge of P^2, or cubical powder, being 370 lbs. In a series of rounds, at a range of about 4,700 yards, the mean error in direction was 1·8 yards, and that of range under fifteen yards. The tube of the experimental gun split during the trials, but it was still in a state to be fired, and at 120 yards sent a projectile through three 8-inch iron plates, penetrating a fourth plate to a depth of two inches. The principle of chambering has been since adopted with this gun, and the diameter of the rear part of the bore has been enlarged to 18 inches. The 80-ton gun has now polygroove rifling, consisting of 32 grooves, each one inch broad, with 'lands' ⅛-inch wide. The projectiles, instead of being studded, are rotated by means of an expanding copper

Fig. 28.



THE 80-TON GUN.

disc—the Elswick Company's gas-check—which stops the erosion of the bore by the escape of gas over the shot, as well as rotates the latter. It is fixed to the base of the shell by a simple cup pressed over a projecting boss. At the moment of firing it is forced into the ratchet cup base of the projectile, compelling it without the aid of studs to follow the twist of the rifling. One of the 80-ton guns has been fired with a charge of 445 lbs. of P^2 powder, and a projectile weighing 1,760 lbs.; the muzzle velocity was 1,657 feet per second, and the total energy at the muzzle 33,710 foot-tons. Should a suitable prismatic powder be found for it, there is reason to believe that this performance can be surpassed. The vent of the 80-ton gun is in line with the axis.

The account which has been given of the successive improvements introduced at the Royal Gun Factory may be summed up in the following extract from the recent volume on armoured ships by Chief Engineer King, United States Navy:—

New Woolwich guns.

'The first distinctive Woolwich guns were constructed in 1865. Prior to that date the guns manufactured at the Royal Gun Factories, of which Sir William Armstrong was then superintendent, had been built on the original Armstrong system. They were rifled breech-loaders, built up with many thin coils of wrought-iron upon a steel inner tube, and rifled on the so-called "shunt" system. In 1865 the first set of modifications was introduced, by which the so-called Woolwich guns thus became distinguished from those of the Armstrong and other rifled systems. These modifications consisted in the definitive adoption of the muzzle-loading system, the improvement of the Armstrong construction by hooking the coils one over the other, and the substitution of the "Woolwich" or rounded simple groove for the "shunt," or sharp-edged compound groove. In 1867 the Fraser modified construction was adopted, in which, instead of the numerous thin coils, a few massive ones were employed, and subsequently the forged breech-piece was abandoned. The value of the enlarged powder-chamber having been demonstrated by experiments, this feature has been adopted for the recent heavy guns; while, in the 80-ton gun—the latest construction of the Royal Gun Factories—the polygroove system of rifling has taken the place of the Woolwich, and studded projectiles have been abandoned for the expanding gas-check. Although these last-named improvements may now be considered incorporated into the Woolwich system, they are features which are possessed by but few of the guns actually in the British service.

'That the Woolwich system has thus been characterised by

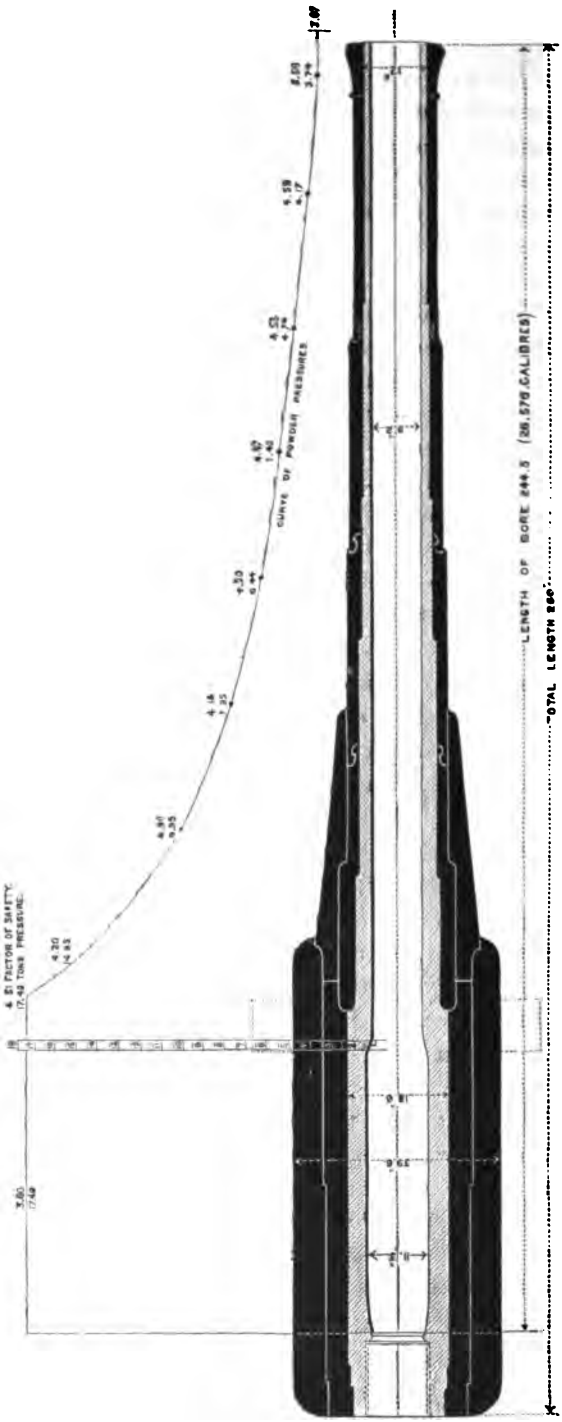
continual changes is in no wise discreditable; it shows rather a laudable disposition on the part of the British authorities to investigate, and if found worthy, to adopt, every proposed improvement and every new device in artillery construction. In the examination and practical trial of the innumerable theories and inventions which have been proposed, vast sums of money have been expended at Woolwich and at Shoeburyness, and in the invaluable results of these experiments the science in general has been allowed to share.

'The explosion of the 38-ton gun on board the "Thunderer" has been the means of directing British official attention again to the whole question of the manufacture of heavy ordnance. In order to act advisedly, the Government has appointed a committee of skilled artillerists; and this committee has already gone so far in the direction of substituting breech-loading for muzzle-loading in the Woolwich system as to recommend the construction of two 43-ton breech-loaders for the "Conqueror," also several other pieces; and these guns have already been commenced at the Royal Gun Factories. It is said that structurally they will not differ materially from the Woolwich muzzle-loaders, the inner tube being, of course, necessarily made thicker in order to provide for the breech-closing arrangement, the method of which has not yet been disclosed. An important feature in the new guns, it is stated, will be the unusual length of bore.' Guns of a similar type, but of different calibres, are being manufactured.

Elswick ordnance factory.

In addition to the Government factory at Woolwich, there is a large private establishment in England, at which the most powerful modern guns have been produced. Sir William Armstrong and Co.'s works at Elswick have acquired a high reputation. Originally started on a small scale, they were joined in 1847 by the eminent engineer with whose name the enlarged establishment has been ever since associated. In 1858, on the completion of an exhaustive series of artillery experiments, the ordnance department was added to the factory. From that year to 1863 this department was practically carried on as a Government establishment. In the latter year the contract with the Government came to an end; and since then many guns have been made for foreign Powers. From the time of starting the ordnance department to the present more than 4,000 guns of all descriptions have been made at Elswick. The works stand on the banks of the Tyne, near Newcastle, and have a river frontage of nearly a mile, and an average width of about 150 yards. They cover forty acres, and as a rule give employment to from 3,500

Fig. 29.



NEW TYPE OF WOOLWICH (9·2 INCH) BREECH-LOADING GUN.

to 4,000 hands. The guns manufactured at Elswick differ but little in the principles of their construction from those made at Woolwich. The latter, as it has been seen, are built up of a small number of heavy coils; in the former the original Armstrong plan of construction is more generally adhered to, and the number of coils is larger.

At Elswick great attention has been paid to the effect of gunpowder when fired under various conditions, both as to space in the chamber and length of bore. The great object has been to add to the power of the gun without increasing the weight. The service 35-ton gun is twelve inches in calibre, and fires a 700-lb. projectile with a charge of 110 lbs. of powder, the penetrating power being represented by an energy of 218 foot-tons per inch of circumference of the projectile. The Elswick gun of the same weight is longer, and fires a charge of 235 lbs. of powder, and a projectile weighing 536 lbs., the penetrative power of which is 356 foot-tons per inch of circumference. The 100-ton guns manufactured by this firm for Italy, and also for our own Government for land service, will be noticed hereafter. The Elswick Company has manufactured several breech-loaders, built upon the same system as its muzzle-loaders. The breech-closing apparatus is modified from that in use in the French navy. But though similar to the French breech-loaders as far as the breech screw is concerned, it is altogether different in the mode of preventing any escape of gas. This is done by using a steel cup, resting upon a slightly convex surface on the face of the breech screw. The edge of the cup is pressed by the screw against a step or shoulder in the gun, so that, when screwed up, the base of the cup is forced to take the form of the convex head, on which it rests, and thus the lip is expanded against the circular surface which surrounds it. When the breech screw is opened, the cup recovers its form by its elasticity, and thereby releases its hold, and comes out on the screw with perfect freedom. The same species of mechanism for closing the breech has also been applied to a 40-ton gun, and very recently to 100-ton guns constructed by the same firm for the Government of Italy.

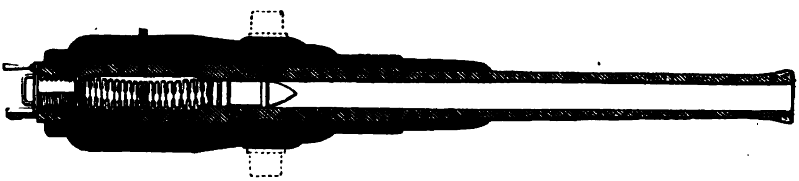
Elswick ordnance.

By recent improvements Sir William Armstrong has succeeded in increasing very materially the power of his guns. By an enlargement of the powder-chamber he has given to his new 6-inch breech-loading gun a penetrative power of 130 foot-tons per inch of circumference, which is ten tons greater at the muzzle than that of the 8-inch rifled British service gun, and only one ton less than that

Recent improvements by Sir William Armstrong.

of the 9-inch gun at 400 yards from the muzzle. The weight of the 8-inch gun is nine tons, or more than double the weight of the 6-inch Armstrong gun. The 9-inch weighs 12 tons, or more than three times the weight of the new 6-inch gun. The smallest armour-piercing gun in the navy is the 7-inch, weighing 6½ tons; the projectile weighs 115 lbs., and its muzzle velocity is 1,525 feet per second. Sir William Armstrong's 6-inch breech-loader discharges a steel projectile of 80 lbs., with a charge of 37½ lbs. of powder, at a muzzle velocity of 2,058 feet per second. The service 7-inch gun is capable of penetrating seven inches of armour at a range of 1,000 yards. Sir William Armstrong's 6-inch gun penetrated eleven inches into a plate thirteen inches thick, at 100 yards. With 21¼ lbs. of powder a steel shell of 100 lbs. went into an 8-inch plate to a distance of more than six inches from the face. With a charge of 31 lbs. of powder a shell of 80 lbs. was driven into an 8-inch plate till the shell's point

Fig. 30.



ARMSTRONG'S 6-IN. GUN (SHOWING CONSTRUCTION).

just reached the back of the plate. With a charge of 17½ lbs. of powder an 80-lb. steel shell was sent through a 6-inch plate.

The power of these guns has been recently increased, and the 6-inch gun has been made twenty inches longer. The increased power is due to this addition to the length, to an alteration in the shape of the chamber, and to an increase in the powder charge to 42 lbs. In comparing the new Armstrong breech-loader guns with the Woolwich muzzle-loader guns, it must be remembered that the power of the latter has been shown capable of increase by adding to the powder charge. Seventy-five pounds of powder can be fired from the 12-ton gun, giving the shell a total energy of 4,400 foot-tons, and nearly 160 foot-tons per inch of circumference.

Comparison of Armstrong and service guns.

The new principles are being applied with equal success to muzzle-loaders and to breech-loaders. An 8-inch gun was completed and tested in 1878. The gun weighs 11½ tons, and the projectiles fired averaged 180 lbs. The results, as recorded in *Iron* on January 11, 1879, were as follows:—

Charge in lbs.	Initial velocity in feet per second	Energy of shot in foot-tons	Highest pressure in chamber. Tons per square inch
70	1,723	3,704	—
80	1,840	4,227	13·3
90	2,027	5,133	15·0
95	2,092	5,458	19·0
100	2,182	5,940	21·3
100 [1]	2,264	5,686	19·0

These results may be compared with those attained in the service guns. The 9-inch gun of 12 tons, with 75 lbs. of P[2] powder, has an initial velocity of 1,520 feet; the 10-inch of 18 tons, 1,364 feet; the 12-inch of 35 tons, with a charge of 110 lbs. of powder, 1,300 feet; and the 12·5-inch of 38 tons, unchambered, with a charge of 130 lbs., a velocity of 1,451 feet per second. The penetrative force of the new Armstrong 8-inch gun, with 95 lbs. of powder, is superior to that of the 35-ton gun, unchambered, with 110 lbs. charge. The 12-inch 35-ton Woolwich gun gives an energy to its projectile of 219 foot-tons per inch of circumference, and this is estimated to carry it through 14 inches of iron at 500 yards. The shot from the new 8-inch Armstrong gun, with 95 lbs. charge, will pass through this target; or, in other words, the new 8-inch gun of 11½ tons is equal to the 35-ton gun in penetrative power.

The Chinese gunboats of the 'Epsilon' class are armed with 35-ton guns of Sir William Armstrong's new pattern. The power of the new ordnance, as compared with that of the guns in use in our service, is effectively contrasted in the subjoined tables, originally published in the *Nautical Magazine*:—

GUNS.

	'Epsilon'	'Dreadnought'
Weight of gun	35 tons	38 tons
Calibre	11 inches	12½ inches
Charge	235 lbs.	160 lbs.
Weight of shot	536 lbs.	818 lbs.
Velocity	1,925 feet	1,445 feet
Muzzle energy [2] . . .	13,769 tons	11,727 tons

[1] This round was fired with a projectile of 160 lbs.

[2] Referring the power of these guns to the weight, the energy per ton of gun is 393 foot-tons for the Armstrong, and 309 foot-tons for the Woolwich gun.

RANGES.

Comparison of the range tables of the service 12½*-inch* 38*-ton gun and the Elswick* 11*-inch* 35*-ton gun.*

Distance of Object	Service 12½-inch 38-ton gun. Elevation	Elswick 11-inch 35-ton gun. Elevation
Yards	Degs. Mins.	Degs. Mins.
500	0 44	0 17
1,000	1 28	0 39
1,500	2 18	1 4
2,000	3 10	1 34
2,500	4 6	2 8
3,000	5 6	2 46
3,500	6 6	3 26
4,000	7 20	4 9
5,000	9 25	5 43

It is impossible to conclude this brief survey of Sir William Armstrong's labours without acknowledging that a spirit of enterprise has been displayed by a private manufacturer which has been wanting at Woolwich. There are influences at work in the public service which tend to discourage invention. No motive power exists leading men out of the beaten track, nor can the stimulus be felt of the competition to which the private manufacturer is subjected.

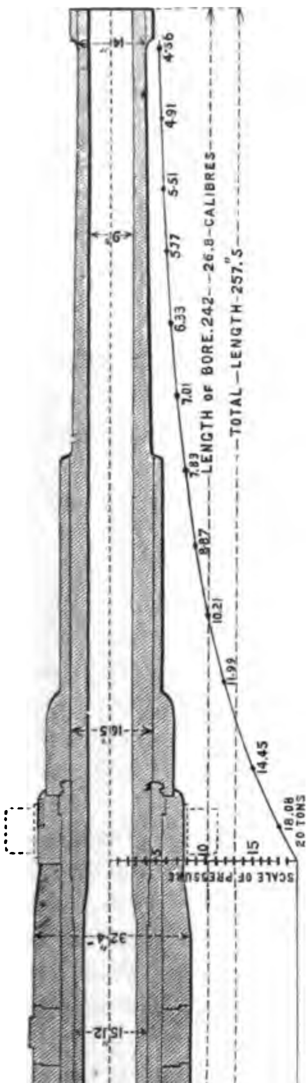
Vavasseur guns—description by Commodore Simpson, U.S.N.

Amongst the guns of new construction, those constructed by Mr. Vavasseur, of the London Ordnance Works, receive the highest commendation from Commodore Simpson. He describes the gun 'as made entirely of steel, and in this respect presenting a strong contrast to the Woolwich gun. In the Vavasseur gun the interior tube of steel is jacketed from the breech to the trunnions with steel, and around the gun thus formed are shrunk hoops of steel.

'Both the Woolwich and the Vavasseur guns have for their basis a steel inner tube; but in the Woolwich system the effort from the first in building up the gun is to suppress the elastic element in the tube, treating it as if it possessed only the dull ductile properties of the wrought iron which encloses it. In the Vavasseur gun, on the contrary, every effort is made to utilise this important characteristic of the metal, and in fact to derive strength from it; not simply making it play the part of a hard lining, depending for strength on the outer coils, but utilising its own inherent strength, and making it take part with the rest of the structure in contributing its quota of the same character of support as is rendered by the outer jacket and rings. In a word, the gun is homogeneous. The inner tube of steel, like the Woolwich tube, is oil-tempered, increasing its elastic properties. This is surrounded by a jacket of the same material, which is not tempered, and which is shrunk on at a very low tension.

This is an important detail in the construction, and the object of it is most reasonable. By shrinking on the jacket at a low tension, producing no appreciable compression of the tube, the tube must develop a certain amount of its elasticity under the pressure of a charge of powder, before it calls upon the jacket for support. In developing this elasticity it has already contributed somewhat towards controlling the force developed in the charge; and, if it receives the necessary support from the jacket before the strain has carried the tube beyond its elastic limit, it will, on the ceasing of the strain, resume its normal dimensions, the jacket of steel acting in like manner. The jacket supplying all the strength required to resist longitudinal strain, the outer support is rendered in the form of the narrow rings of steel. These are shrunk on at a high tension, the effect being to compress the inclosed jacket. We thus have in the Vavasseur gun what seems to be the most perfect theoretical arrangement of material, where each part is so adjusted to the other as to render at the same moment a united support.

Fig. 31.



VAVASSEUR 13·5-TON GUNS.

'The Woolwich gun has the stamp of Government approval on its side, but the Vavasseur gun must be recognised as being in all respects the most truly scientific, and as promising more endurance. The cheaper construction of the Woolwich gun is, of course, an important point to be considered by Government officials, and it may be that this consideration has had much to do with their conclusions in adopting the gun; but if the expense of retubing after a limited number of fires were to be added to the original cost,

it might be found that the gun that was the dearer in the beginning would prove cheaper in the end.

'The only gun in England with which the Krupp gun can be properly compared is the Vavasseur gun. The essential point of difference lies in the use by Mr. Vavasseur of the cylindrical jacket, which is shrunk around the tube before the hoops are placed in position. In the Vavasseur construction this piece is necessary to supply strength in the direction of the length, as the tube is only two-ninths of the calibre in thickness; but Mr. Krupp is able to dispense with the jacket in consequence of the greater thickness which he gives his tube, which, at the seat of the charge, is about three-fourths of the calibre, while at the muzzle it is reduced to three-eighths of the calibre.

'In the Vavasseur gun the chase is reinforced with rings shrunk on, but until lately the Krupp gun has had to depend on the thicker tube to supply the strength required at this point. The neglect to build up on the chase has in several instances proved disastrous to the gun, and it is understood that in the future the Krupp gun will have rings on the chase.'

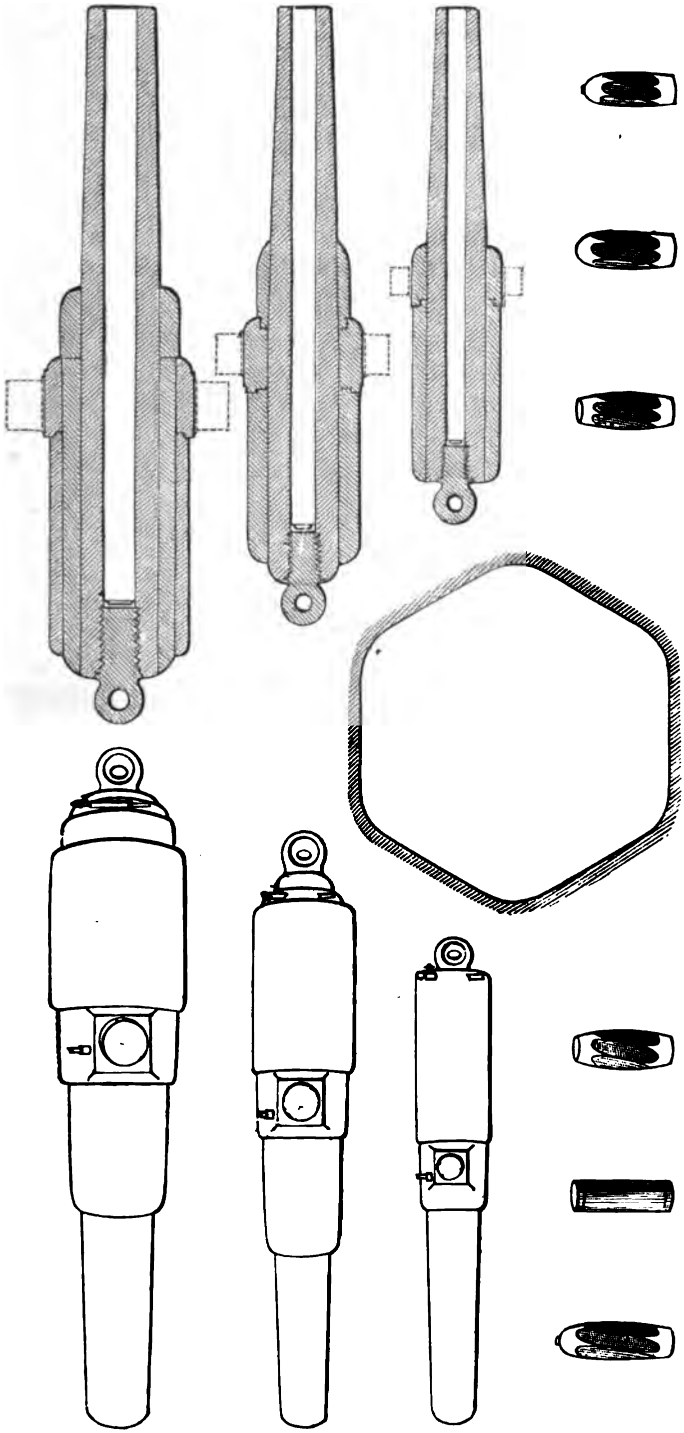
Whitworth ordnance.

Herr Krupp is justly entitled to great distinction as an artillerist; but it is fair to state that his claims to merit as an inventor must be largely shared with Sir Joseph Whitworth. The latter was the first to show how steel could be manufactured of such a quality as to be capable of resisting the powder strain. He introduced the polygonal method of rifling, with its large surfaces of bearing, the powder chamber, and barrels of sufficient length and diameter to burn the charges required.

Lieutenant Very, of the United States Navy, says:—'Whitworth ordnance is almost exclusively used in the Brazilian navy. The Whitworth construction belongs to the "all-steel" type, and differs in almost every particular from the other types. The guns are both muzzle- and breech-loaders. The body of the gun consists of a steel tube reinforced by steel hoops. The tube is cast solid, and submitted to a heavy hydraulic pressure while in a molten state, giving the metal as it solidifies a perfectly homogeneous crystallisation throughout. This tube is bored completely through, and in the muzzle-loaders the breech-end is closed by a steel screw-plug. The hoops are hollow cast and forged on a mandrel, the lengths in the different layers being accurately turned and screwed together. The layers are then put on the gun, and—though originally forced home cold from the muzzle-end—are now understood to be shrunk on hot.

'The breech-loaders are slotted across the rear face in such a

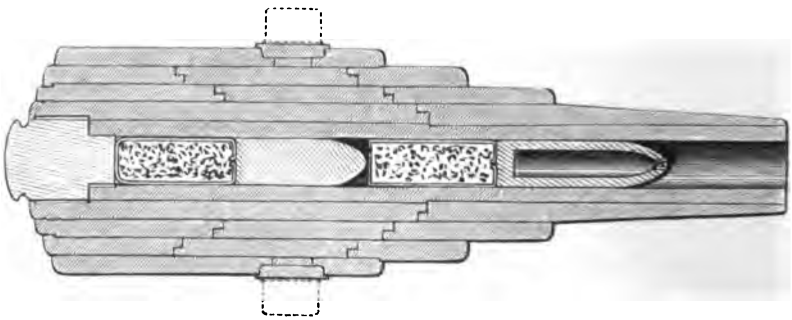
Figs. 32 to 44.



EARLIER MUZZLE-LOADING WHITWORTH GUNS (SHOWING SECTION OF BORE AND PROJECTILES).

manner that the rear face of the block is entirely exposed, thus saving in length of breech of gun. The breech-block is cubical, and is traversed along the upper and lower surfaces by heavy threads, set at an angle with the face of the block. These threads travel in heavy female threads in the slot, the system forming the support for the thrust on the block. Attached to the rear face of the block is a weighted crank, which revolves a cogged wheel housed in the block, and travelling in a rack in the rear of the lower side of the block-seat. In guns of heavy calibre the system is reversed; the crank and wheel housing in the rear of the gun and the rack in the block. By means of this gearing the block is moved transversely, masking and unmasking the bore, the left end of the block being cut for a loading-hole. A stop in the face of the breech locks the block when home and catches it at the proper point when open.

Fig. 45.



WHITWORTH 12-IN. GUN (SHOWING POSITION OF DOUBLE CHARGE).

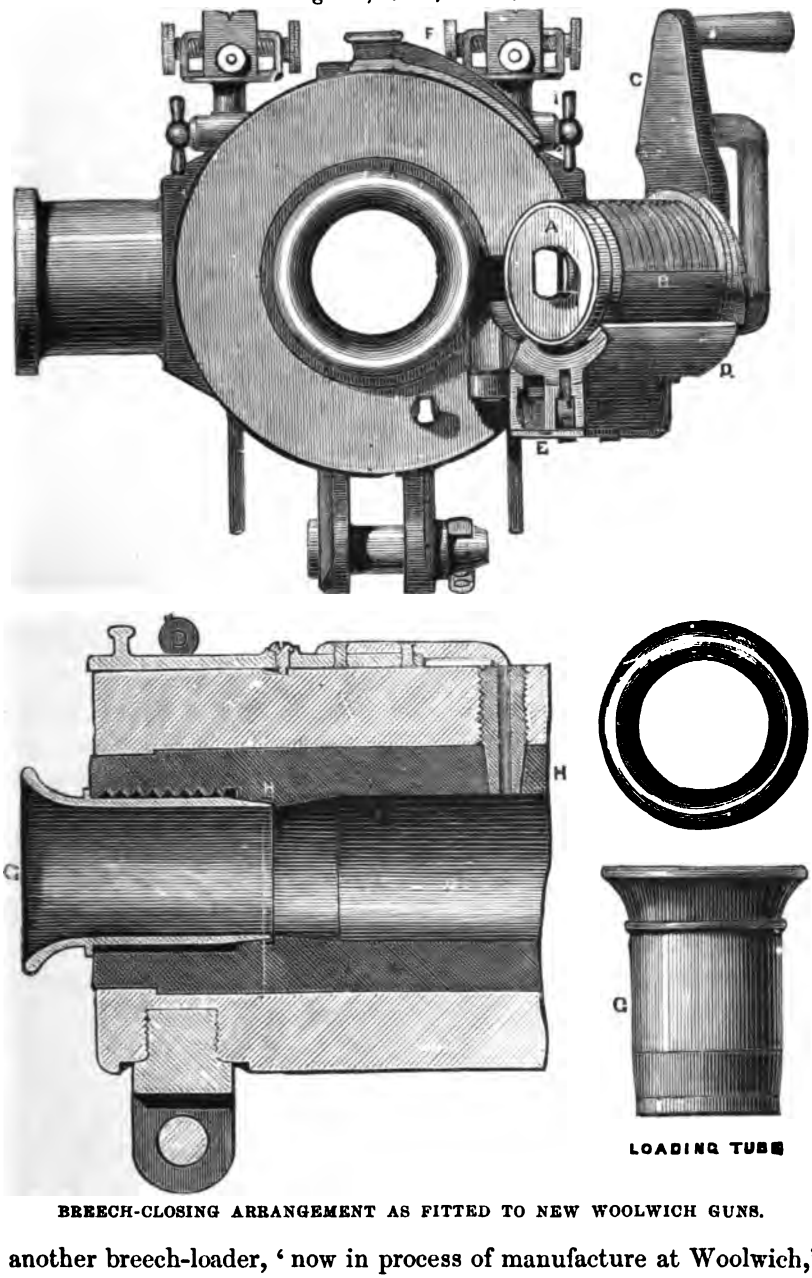
'The Whitworth groove is of a peculiar nature, the bore being almost a perfect hexagon, and having an extremely sharp twist of from one turn in two feet in the 2-pounders to one turn in thirteen feet in the 9-inch. The projectiles are cut to fit the grooves, the armour-punching ones being of compressed steel.'

Before the present conflict between Chili and Peru the Whitworth guns had perhaps been used in actual war to a greater extent than any of the existing naval heavy rifled guns, many of these steel pieces having been on board the Brazilian ships in the Paraguayan war. If they were ordered as late as the date of the equipment of the 'Independencia,' it is clear that Brazilian officers were satisfied with their experience of them.

Mr. King. Newest British guns. In Mr. King's latest work it is stated that the British Government are about to have guns of about 43 tons weight, loading at the breech, constructed to arm the turret-ships 'Conqueror,' 'Majestic,'

and 'Colossus.' These guns are to be of very much greater power than the 38-ton gun. The same book contains a short account of

Figs. 46, 47 48, and 49.



BREECH-CLOSING ARRANGEMENT AS FITTED TO NEW WOOLWICH GUNS.

another breech-loader, 'now in process of manufacture at Woolwich,' weighing 18 tons. The author says:—

'Its great length of bore, as compared with the older Woolwich guns, is apparent. The parts are much more numerous, there being seven wrought-iron coils, beside the breech-piece and steel tube, where the old 9-inch gun had but two coils beside breech-piece and tube. It will be seen that the Woolwich method of locking the coils together by hooks has in the after coils of this gun been departed from, dependence being placed upon the bite secured by shrinkage, in the same manner as in the Armstrong arrangement. The steel tube is considerably increased in thickness, especially the portion immediately in front of the powder-chamber, which has a diameter 2·1 inches greater than the rest of the bore. The breech fermeture is a screw-plug, after the French system.

'It will be interesting to make a comparison between this gun and the old 9-inch piece now in the service. The great change in dimensions, and the remarkable anticipations of increase in power, merit attention.

	Old 9-inch.	New 9·2-inch.
Calibre, in inches . . .	9	9·2
Weight, in tons . . .	12	18
Length, in inches . . .	147	260
Length of bore, in inches . .	125	244·5
Weight of projectile, in pounds .	250	320
" charge " .	50	160
Initial velocity, feet per second .	1,420	2,025 (estimated)
Total energy, foot-tons . .	3,496	9,096 "
Energy per ton of gun, foot-tons .	291	505 "

'The greatest diameter of the new gun at the breech is 39·6 inches, and the smallest diameter near the muzzle is 15 inches. The external diameter of the steel tube at the breech is 18·75 inches, and at the muzzle it is twelve inches.'

French naval ordnance.

The guns for the French navy and for the armament of certain coast batteries are manufactured at Ruelle or Nevers, unless in exceptional cases, when a portion or the whole of the work is done by some eminent firm of private manufacturers. The latter course has been adopted in the case of the 72-ton steel guns, which have been ordered but are not yet mounted afloat. Ruelle is in the Department of La Charente, and has been used as a gun factory for more than a century. Until 1776 it was the property of private owners, but since that date it has belonged to the Government. The Nevers foundry[1] is much more modern, having been established in 1830. These factories are under the Ministry of Marine. The French navy, unlike that of Great Britain, manufactures its own guns, or purchases those required under the direction of its own officers. As early as the Crimean War experiments were made in France on a

[1] It has very recently been closed.

large scale in rifling cast-iron guns. Trials were afterwards recommenced at Lorient; and in 1860 the system of constructing guns of cast iron with breeches strengthened with steel rings or hoops was adopted. The heavier of these pieces were smooth-bores; and visitors to the Paris Exhibition of 1867 may remember seeing the largest breech-loading gun then constructed in France, with its spherical shot, in the grounds of the Champ-de-Mars. The present system was determined on ten years ago by the then Director of Naval Ordnance in Paris. The date 1870 thus gives its name to the pattern at present in use, though it was not until the conclusion of the war in the following year that the manufacture of the pieces made according to it was begun.

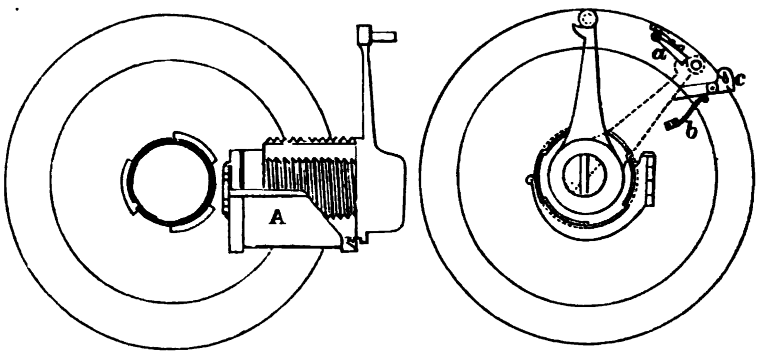
The Ruelle cast iron shows a high degree of regularity when tested. After having been submitted to suitable tests, it is mixed with other irons from neighbouring mines, and sometimes with English and Spanish irons. The material thus obtained is again tested. The present pattern of gun consists of a cast-iron body, lined as far as the trunnions with a steel tube forced into the body; while externally the breech up to the trunnions is reinforced with rings of puddled steel shrunk on to the body. The chase is left unstrengthened. The cast-iron portion is cast hollow, the trunnions being put on afterwards. The mould is inclosed in an iron flask, and is placed upright in the casting pit with the muzzle downwards. Two small pits are made on each side of the casting pit, from which channels lead to the mould at different heights. The metal is poured in through these in succession, until the casting is completed. The head is then covered up with charcoal, and the whole is left in the pit for 48 hours. It is then taken out and the cone removed, and the piece turned and bored. The body is subsequently annealed in a brick cylinder heated with charcoal to a temperature of 540° Fahrenheit. The steel tube is then screwed in, and the whole allowed to cool. The outside rings are afterwards shrunk on, the trunnions being on the first. The gun is then rifled, and has as many grooves cut in it as there are centimètres in the diameter of the bore when the number is even; when odd the number of grooves is one in excess. French guns of the 1870 pattern are therefore polygrooved, a system not adopted for any of the Woolwich guns yet mounted afloat, except the 80-ton guns of the 'Inflexible,' which are so rifled. These French rifled breech-loaders have another peculiarity, which is not yet to be found in any heavy guns carried by English ships of war, except those just mentioned. This peculiarity is the enlarged powder-chamber, which, though of moderate dimensions compared with those since approved for Sir

William Armstrong's and the newer Woolwich guns, is to be found in the French weapons of the 1870 pattern. The endurance of the latter is stated to be very great. French officers declare that the occurrence of an accident even at proof is quite unknown; and Captain Sebert is quoted by Commodore Jeffers of the United States Navy as reporting that '*Pas un seul accident de rupture n'est survenu,*' although in target practice and on board the gunnery ship between 50,000 and 60,000 shots had been fired with common and battering charges.[1] French guns vary in length from 21 to 28 calibres, being generally of the shorter dimension. The 9·4-inch gun, with steel lining, trunnions, and rings, costs about 580*l.* The English gun of the nearest corresponding nature costs about 740*l.*

Cost of French, compared with English guns.

The breech-closing arrangement is similar to that in use with

Figs. 50 and 51.



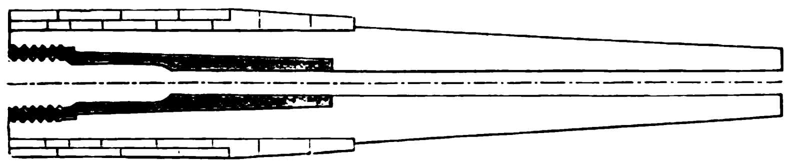
FRENCH BREECH-BLOCK (OPEN AND CLOSED).

the new Armstrong guns already described. It consists of a cylindrical block of steel on which a screw thread is cut. Portions of this thread are cut away, leaving three blank spaces on the block; and in the female screw cut in the breech of the gun three similar blank spaces are also left. The remaining threads on the breech block are brought opposite the corresponding spaces in the breech, and the block can be forced in to nearly the full extent, when one-sixth of a turn brings the screw into play and firmly secures it. The same fraction of a turn frees the screw and allows it to be drawn out. It rests upon a bracket hinged at the side of the breech, so that it can be turned aside out of the way when the gun is being loaded. The vent is in the axis through the breech block, and all escape of

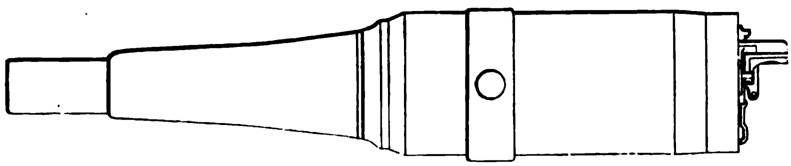
[1] It is reported that early in 1880 the breech screw of one of the new 38-ton French guns blew out during experiments. A second gun of steel is also said to have burst; this latter statement, however, requires confirmation, as it has been denied by the authorities.

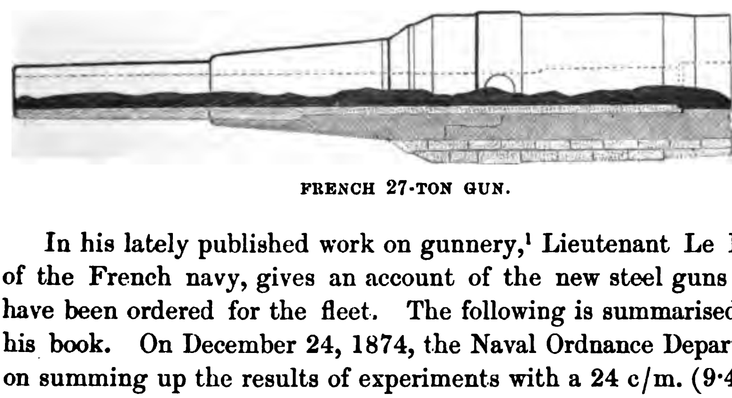
gas through it is stopped by an ingeniously arranged slide, which acts automatically as the breech is being closed. Till that operation is completed the gun cannot be fired. A hammer and a small percussion cartridge are used for igniting the powder charge. The gas-check for stopping the escape of gas to the rear, which is called the *obturateur*, and which should be distinguished from the other gas-check, which stops the escape of gas over the projectile and rotates it, consists of two copper rings, one in the face of the block and the other in the breech, which come in contact when the breech block is screwed up.

Figs. 52, 53, and 54.



FRENCH 27 C.M.





FRENCH 27-TON GUN.

In his lately published work on gunnery,[1] Lieutenant Le Barzic, of the French navy, gives an account of the new steel guns which have been ordered for the fleet. The following is summarised from his book. On December 24, 1874, the Naval Ordnance Department, on summing up the results of experiments with a 24 c/m. (9·4-inch) steel gun, suggested the adoption of guns of this calibre made of steel, with exterior hoops and a short inside tube, firing a charge of powder of 32 kilogrammes (70½ lbs.), which should give a velocity of 470 metres (1,542 feet a second) to a shot weighing 144 kilogrammes (317½ lbs.). These pieces were to be mounted only aboard ship. The restrictions imposed on the designers were occasioned by the costliness

Lieutenant Le Barzic on the newest French guns.

[1] *Manuel d'Artillerie.* Paris, 1880; pp. 213–17.

of steel pieces, it being found that two guns of steel cost the same, and take the same time in manufacture, as five of cast-iron hooped and tubed as in the 1870 pattern. It was also estimated that an 18-ton gun of the 1870 pattern would cost 920*l.*, whilst a 24 c/m. steel gun of the same power would cost 4,000*l.* In this case, however, the latter, with its supply of ammunition, would be six tons heavier than the former. In the end, the Minister of Marine decided that steel by itself should be employed for the construction only of guns of 27 c/m. (10·6-inch) calibre and upwards.

The 27 c/m. steel gun is composed of an inside tube, of a gun-body, and two layers of hoops. The tube is of Bessemer steel, forged, and tempered in oil; and the hoops are of puddled steel made at the works of Messrs. Petin and Gaudet. The gun-body, made of steel of the same kind, was forged at Rive-de-Gier. It is formed of two parts brought together hot and clamped. The front of the breech-portion is inserted into the chase-portion, the latter having been previously heated. The gun weighs 24 tons. When tried with a charge of 47 kilogrammes (103½ lbs.) of cubical Wetteren powder, it gave to a projectile weighing 216 kilogrammes (476 lbs.) a muzzle velocity of 1,525 feet a second. This has apparently been since exceeded. In the table of French ordnance in the 'Carnet de l'Officier de Marine' (p. 103 *bis*), the muzzle velocity is given as 1,656 feet a second, with the same powder charge and projectile. After more than 500 rounds with these charges the gun underwent a further test, firing 70 rounds with charges of 110¼ lbs. of powder, the projectiles weighing from 553 lbs. to 637 lbs. Four guns of the pattern were therefore made at Nevers for issue to the service—they are designated the '1870–75 pattern, No. 2, steel.' At the same time the Minister of Marine directed some guns of another pattern, distinguished as the No. 1 pattern, to be made. They are of the same calibre, but heavier. They weigh nearly 28 tons, and have a projectile of 553 lbs. Several steel guns of 70 tons weight are at present being manufactured. In M. Le Barzic's table of French and other ordnance (p. 225), he gives a steel gun of 47 tons firing a projectile of 882 lbs. Its calibre is 34 c/m. (13⅓ inches).[1]

French projectiles.

The projectiles used in the French navy are:—(1) chilled iron or steel shells; (2) common shells of cast iron; (3) armour-piercing shells of chilled iron or steel; (4) shrapnel shells. When sufficient armour-piercing shells have been made, those designated (1) will be no longer used.

[1] It is impossible to give the weights and dimensions of the new French steel guns, the figures not having been published.

The powders used in the French land and sea services are different. In the navy Wetteren powder is used. There are five kinds, differing in the number of grains to the pound, which are used with guns of various calibres. The system of manufacture at Wetteren, up to the first process of granulation inclusive, resembles that adopted in other countries. The products of the first granulation, cannon-powder, musket-powder, and meal, are mixed together and formed into a cake under hydraulic pressure. This cake is then cut into grains by means of a machine containing two bronze knives, and the grains are sifted. The following table shows the ingredients and size of grain of French naval powders:— French gunpowder.

Naval Large Grain Powders (Wetteren or a³ of Le Bouchet).

	10 c/m. to 13 c/m. gun	13 c/m. to 16 c/m. gun	16 c/m. to 20 c/m. gun	20 c/m. to 25 c/m. gun	25 c/m. to 30 c/m. gun
Saltpetre	75	75	75	75	75
Sulphur	10	10	10	10	10
Charcoal	15	15	15	15	15
No. of grains to the lb.	322	164	103	50	26
Density	1·780	1·782	1·806	1·787	1·805

The guns carried by the ships of the German Empire are those of the pattern usually known as Krupp's. In some cases the design of the Government weapon differs somewhat from that adopted by this eminent maker for guns supplied to foreign Powers. German naval guns.

We have seen how vigorous has been the competition of our own private manufacturers with the Government establishment at Woolwich. On the Continent, Woolwich stands face to face with the even more formidable competition of the great establishment of Essen. The following comparison of the German and English guns appeared in the *Fortnightly Review* in 1879, in an article from the pen of an officer of the Royal Marines. The subjoined table is taken from the article in question:— Krupp guns.

German Ordnance			English Ordnance		
Nature of Gun	Muzzle Velocity in Feet	Muzzle Energy in Foot-tons	Nature of Gun	Muzzle Velocity in Feet	Muzzle Energy in Foot-tons
12-inch, 36 tons	1,525	10,510	12-inch, 35 tons	1,300	8,200
11-inch, 27 tons	1,640	9,699	11-inch, 25 tons	1,315	6,415
10-inch, 22 tons	1,575	7,122	—	—	—
10-inch, 18 tons	1,509	6,553	10-inch, 18 tons	1,364	5,160

The power obtained for the weight carried by ships armed with these guns would be as follows for each ton of gun:—the German

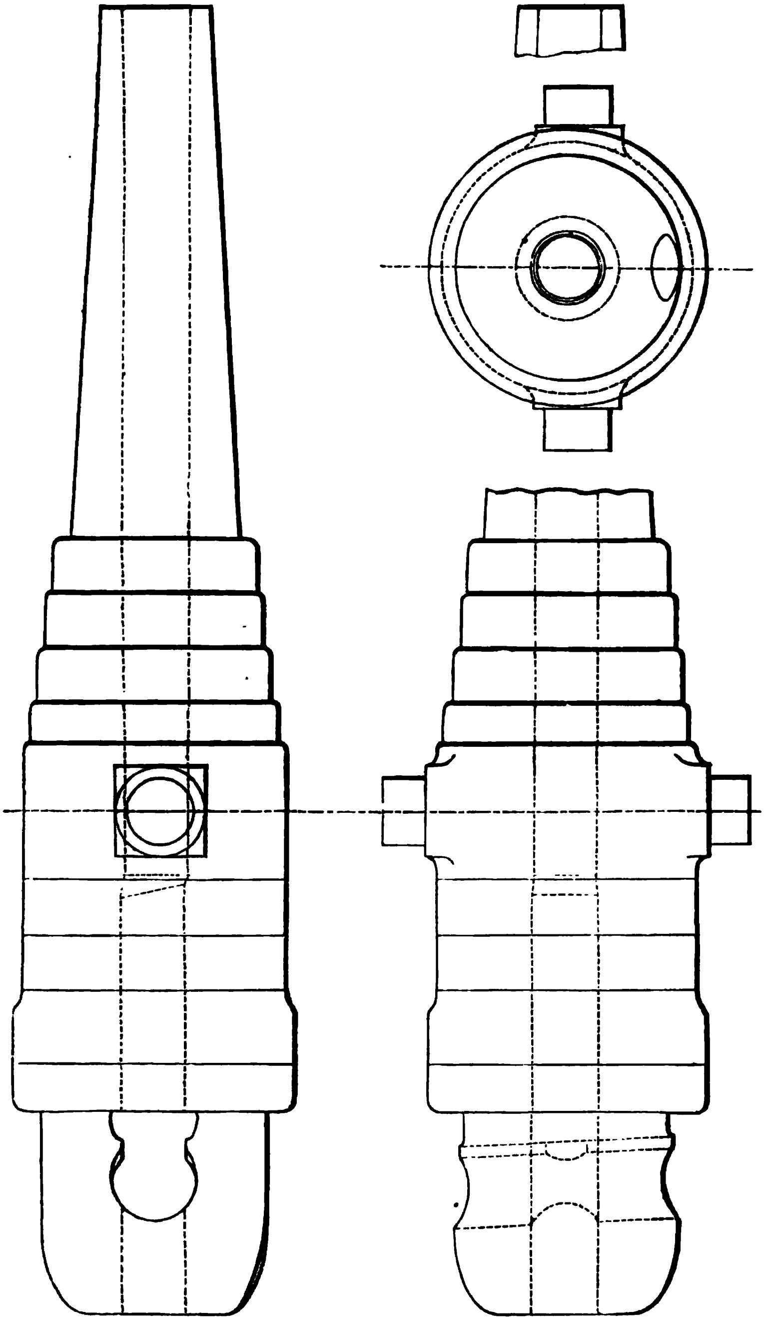
36-ton gun has 292 foot-tons of energy, the Woolwich 35-ton gun 235; the German 27-ton gun 359 foot-tons, the Woolwich 25-ton gun 257 foot-tons; the German 18-ton gun 362 foot-tons, the Woolwich gun of the same weight 287 foot-tons.

Many of the naval guns of Germany are made from designs of the Committee of Ordnance. Occasionally, if not invariably, the rough barrels are supplied by the manufacturer; whilst the boring, rifling, and fitting of the breech-closing apparatus are performed under the immediate superintendence of officers of the Government. Herr Krupp's works at Essen are on a gigantic scale, about 9,000 men being employed in them, whilst 5,000 more are at work in mines and blast furnaces belonging to the proprietors. The Essen factory was established in the year 1810. It was conducted by Herr Friedrich Krupp from the year 1826, and taken over by him on his own account in 1848. The ordnance department occupies only a portion of the establishment. Besides the proof butts at Essen, where all guns and carriages made in the factory are tested, the firm has an extensive range near Dulmen, in Westphalia, for ballistic trials, etc. This range has a length of nearly 8,000 yards, so that trials for almost any distance required can be carried out. In addition to the Dulmen range there is one of much larger extent at Meppen, where extended experiments are carried out. This range is ten miles and a half long and two miles and a third wide.

The guns manufactured at Essen are said to be made from crucible cast-steel of a quality especially suitable for the purpose. At first Herr Krupp forged his guns from a single block, but he has in his latter patterns reinforced them by rings of steel, at all events for those of large calibre. The rings are shrunk on, being put on hot and allowed to cool. The rings in front of the trunnion-ring are caught in annular grooves scored in the subjacent metal. It is stated in a report of a Committee of Swedish officers, who visited Herr Krupp's works, that his method of producing steel is a secret. After casting it is hammered and rolled to remove porousness, and is afterwards submitted to a series of exacting tests. What rendered its being employed for the construction of heavy pieces difficult at first were the technical difficulties of manufacture and of controlling the work. At Essen, so much experience has been gained that the necessary security seems to have been acquired. The price of Krupp's guns is high; about four shillings a kilogramme as against two shillings and sixpence charged by Armstrong and Co.

The breech-closing mechanism of the Krupp gun is on the 'wedge' plan. The breech of the gun extends for a considerable

Figs. 55 and 56.

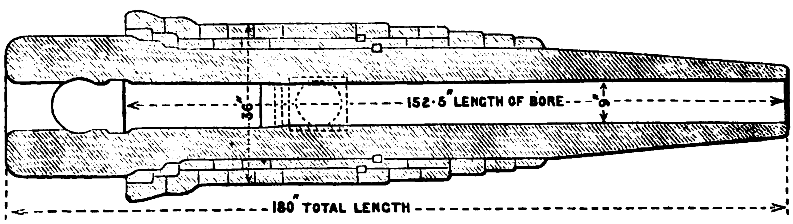


9-IN. KRUPP STEEL GUN (EARLIER PATTERN).

distance in rear of the powder-chamber, which is of somewhat larger diameter than the bore, the gun being, in fact, 'chambered.' This

additional length is the weak point of wedge-closed breech-loaders, as it increases the unwieldiness of the gun without in any way adding to its ballistic power. At the back of the last strengthening steel ring a slot is cut through the gun horizontally. In it slides to and fro the cylindro-prismatic, or round-backed ᗡ-shaped wedge or breech-block. In the face of this block a shallow circular recess is formed of a diameter somewhat larger than that of the powder-chamber, and in this recess is placed a steel plate, having at the back a thin disc of copper interposed between it and the metal of the breech-block. When the latter is in the firing position the plate is exactly opposite the end of the chamber with which its diameter corresponds. A ring with annular grooves at the back to receive particles of the fouling, when the gun has been fired, is pressed against by the steel disc when the wedge is close home, the gas escape being prevented by this arrangement, which is the invention of Mr. Broadwell, an American. A quick-motion screw turned by a lever runs the wedge quickly in

Fig. 57.



EARLIER KRUPP 14½-TON GUN.

and out; and in the larger guns it is secured in its place by a locking arrangement which resembles a screw, with a portion of the thread removed, working in the block and the solid portion of the gun. A hole in the wedge, when the latter is open, comes opposite the chamber, thus forming a continuation of the bore through which the charge is introduced. The heavier guns are vented in the axis, the escape of gas being prevented by an ingenious contrivance. This consists of a ball inserted in a cavity in the vent channel, which is pushed aside by the fire from the priming tube, and pressed back against the opening into the cavity, when the charge has been ignited, by the gas formed.

German projectiles. The projectiles formerly used with the German guns were coated with lead; but this pattern has since been abandoned, and some with two copper bands have been adopted in their place. These bands are gripped by the narrow grooves of the polygroove rifling. One band is near the shoulder of the projectile and centres the shot; the

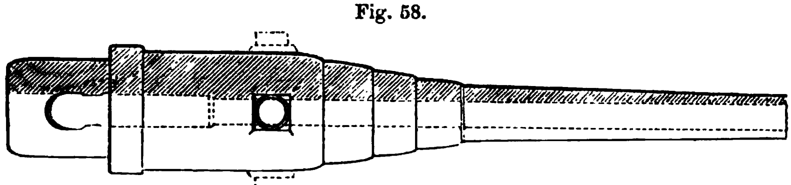
other is near the base and acts as a gas-check. Mr. Gruson, of Magdeburg, manufactures a large number of chilled cast-iron projectiles for the German service. The powder used is made in hexagonal prisms about one inch thick, each side of the hexagon being also about one inch in length. For the heavy guns these prisms are perforated by a single channel in the centre; for the lighter pieces there are seven perforations in each prism.

German gunpowder.

Meppen experiments.

Like the great English firm of Sir William Armstrong and Co., that of Krupp has lately constructed guns of very exceptional power. Full reports of the important gunnery experiments on Herr Krupp's practice-ground at Meppen, in North Germany, at which his most important new guns were tried, have appeared in the English newspapers, from which the following accounts are taken. The largest gun is the 71-ton of 15¾-inch calibre. Its length, 32 feet 9¾ inches, exceeds that of the 100-ton gun by nearly two inches, and that of the Woolwich 80-ton gun by six feet. It has attained a muzzle velocity of 1,703 feet a second with a charge of 485 lbs. of prismatic powder. With the

Fig. 58.



KRUPP'S BREECH-LOADER (NEW PATTERN).

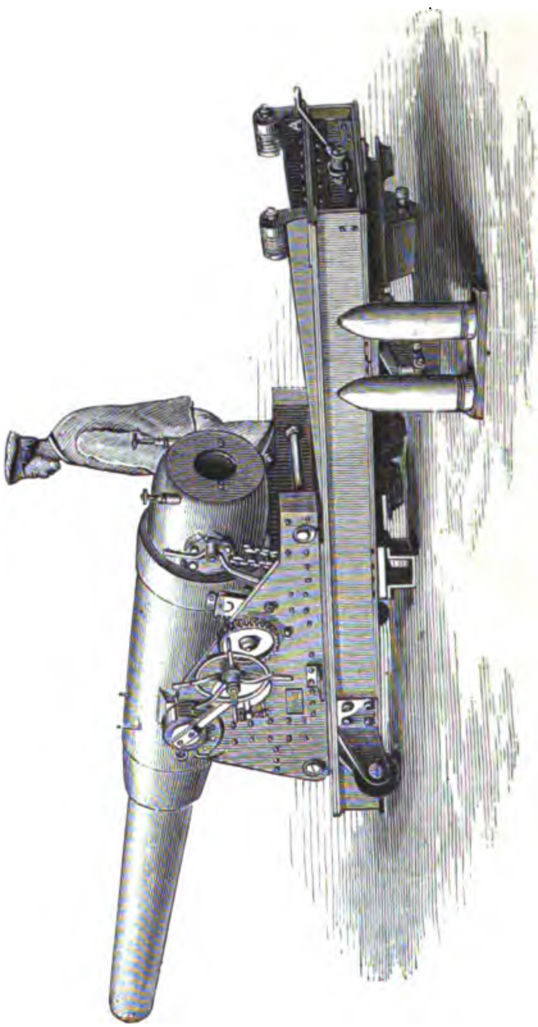
shell then fired, weighing 1,716 lbs., this gave a total energy of 34,490 foot-tons, a work per inch of circumference of the projectile of 697·1 foot-tons, and a calculated penetration of 33½ inches of iron. The gun is made of soft steel, worked and built up in four successive hoops over the central steel tube. It is chambered, and has polygroove rifling, having ninety grooves with a uniform spiral, as have all Krupp's guns. When fired at Meppen the charge was 452 lbs. of prismatic powder entered in four separate cartridges, and the weight of the shell as 1,712½ lbs. The mean muzzle velocity was 1,602 feet per second. The accuracy of shooting was remarkable; eight shots made a group of holes the centres of which, at 2,700 yards range, fell within a space measuring six feet horizontally and eight inches vertically.

The next in size is a 51-ton 14-inch gun with a total length of 29 feet. It fires a charge of powder of 253 lbs., and a battering shell weighing 1,155 lbs., and with these attained a muzzle velocity of 1,627 feet a second, and a total energy of 24,235 foot-tons.

A new naval gun of 9·4-inch calibre weighs 18 tons, and has a

length of bore of 17 ft. 9 in. When fired with 165 lbs. of powder and a battering projectile of 350 lbs., it gave a muzzle velocity of 1,910 feet a second. It was fired at Meppen at two armour-plates of German manufacture, one of twelve inches, behind which was a second of eight inches thickness, with a thin layer of some six inches of deal

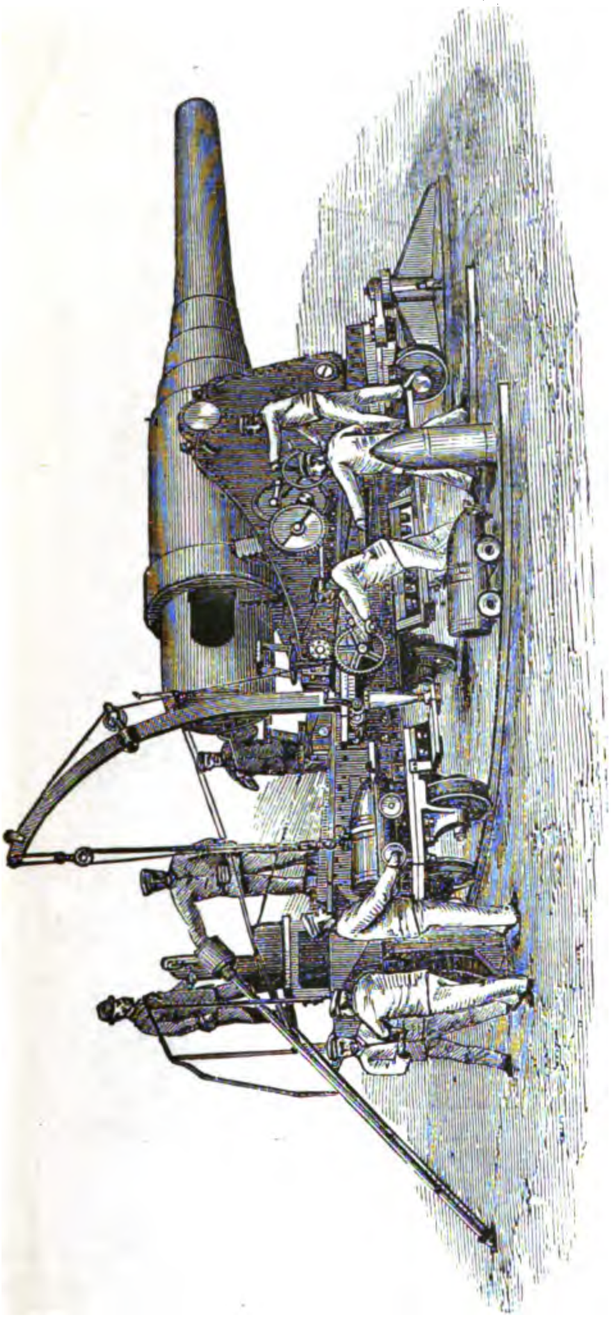
Fig. 59



6-IN. KRUPP GUN ON NAVAL CARRIAGE (NEW PATTERN).

between them. The projectile was of forged steel, and the range 164 yards. Two rounds were fired at this target, and both shots went right through the two plates, the first ranging 3,300 yards beyond, and the second nearly the same distance. The plates, however, seem to have been inferior in quality.

Fig. 60.

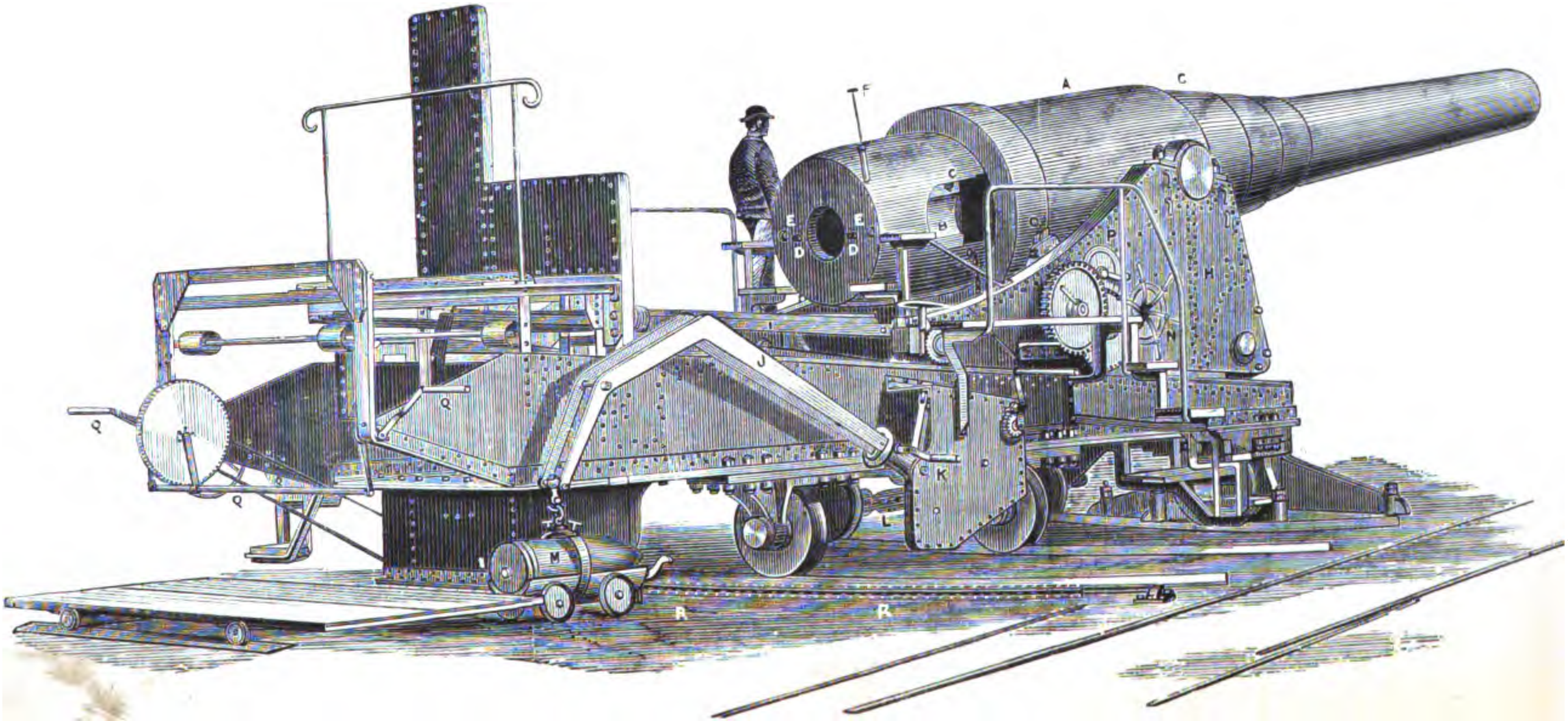


51-TON KRUPP B.L. GUN.

Krupp 4-ton guns.

Mention has already been made of an Armstrong 6-inch breech-loader, which equals in penetrative power existing service guns

Fig. 61.



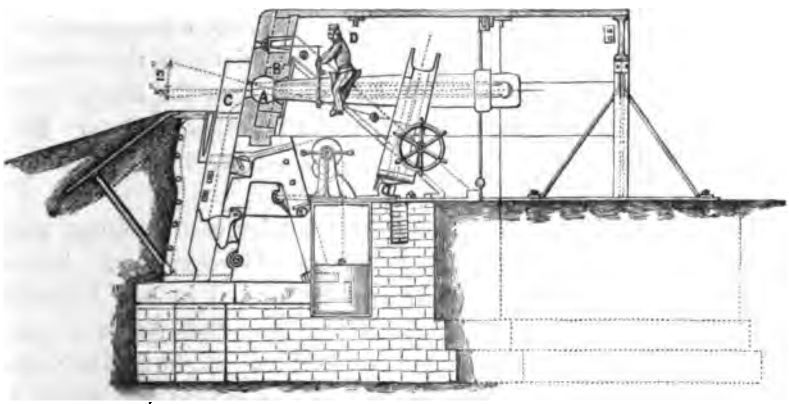
71-TON KRUPP B.L. GUN.

several times its weight, which is less than four tons. Herr Krupp has constructed a gun of approximately similar dimensions, the performances of which it may be interesting to examine. This gun has a 6-inch calibre, is twelve feet long, weighs four tons, and fires a chilled projectile of 112 lbs. with 33 lbs. of powder. With that charge it gave a muzzle velocity of 1,668 feet a second; and with an 88-lb. projectile a muzzle velocity of 1,835 feet. This piece is specially intended for sea service, and could be mounted with advantage on board unarmoured ships. The Russian cruisers of the 'Rasboynik' class carry guns of very similar design and power.

Muzzle pivoting.

The eminent German manufacturer has invented a remarkably ingenious system of muzzle pivoting, in which the gun is protected by armour. This he has at present applied to no larger gun than

Fig. 62.



KRUPP'S MUZZLE-PIVOTED GUN.

one of 15½ c/m. calibre, that is, a little more than six inches. It weighs 65 cwt. On the muzzle of the gun is screwed a sphere, which has a female-threaded perforation of a sufficient size to take the screw on the gun. This sphere works in a cavity in the armour-plate, where under ordinary circumstances the port would be pierced, and forms a ball-and-socket joint. The gun can then be elevated, depressed, and trained to the right or left on the pivot so formed. Aim can be taken through a small hole immediately above the orifice at the muzzle which is cut through the armour to permit the egress of the shot. A sight is fitted to this hole and connected with the gun, so that the latter can be accurately laid by a man astride upon the chase. The whole of the recoil is absorbed by the structure in which the muzzle works. Being a breech-loader there is no occasion to run the gun either in or out; whilst the operation of removing it

can be carried out by unscrewing the sphere from the muzzle, when the piece can be withdrawn. It has not been seriously proposed to adopt this plan in the sea-service. The gun is of a nature which it has not been considered requisite to place behind armour when mounted afloat; and wherever armour is now carried it is thought proper that it should be of greater thickness, and be combined with more powerful weapons than that which protects the muzzle-pivoting gun, and of a thickness which could not be penetrated by pieces of only 6-inch calibre at any important range. It may prove useful for gunboats for river service likely to engage only field artillery or the guns of inland fortresses. Herr Krupp has also invented some methods of central pivoting for guns of great length and restricted weight, which enables an all-round fire to be maintained, and seems applicable to boats. He has proposed to apply this method to heavier pieces in specially constructed gun-vessels. The great power evinced by these recent Krupp guns appears more striking, when attention is paid to the fact that they do not differ materially in the essential features of their design from the guns which have for several years been carried by German ships and those of other nations. They might be substituted for the latter without serious inconvenience or much change in the fittings of the vessels.[1]

Herr Krupp's letter to the *Times*, March 1877.

It has been asserted that a large proportion of the Krupp guns were rendered unserviceable in the Franco-German war. An explanatory statement on this subject was published in the *Times* in March 1877, by Herr Krupp. He stated that the damaged guns, with the exception of four or five, required only slight repairs; that the guns had suffered from the escape of gas caused principally by the double wedge giving way; but none had burst. The Saxon artillery, being of a more recent pattern, had not failed. Summing up the general results from a practical trial with his guns, Herr Krupp said that since the commencement of the manufacturing of steel ordnance in 1847, he had supplied upwards of 17,000 guns of all calibres, of which only eighteen, or one gun in 948, had failed. By far the larger part of these eighteen failures had occurred through the breaking away of the breech, owing to its then rectangular form, which had since been altered to semicircular, and not a single mishap had since occurred.

Italian naval guns.

The Italian navy is armed chiefly with guns of the English pattern. 'Its armament,' says M. de Poyen, 'is almost the same as that of the British fleet.' The following guns are carried by the men-of-war of Italy:—

[1] See *post* tables of new Krupp guns, pp. 118–9.

28 c/m. (11-inch) Armstrong gun.
25 c/m. (10-inch) „ „ No. 1.
25 c/m. (10-inch) „ „ No. 2.
22 c/m. (9-inch) „ „
20 c/m. (8-inch) „ „
16 c/m. (6½-inch) cast-iron tubed gun.
16 c/m. (6½-inch) cast iron, strengthened with rings.

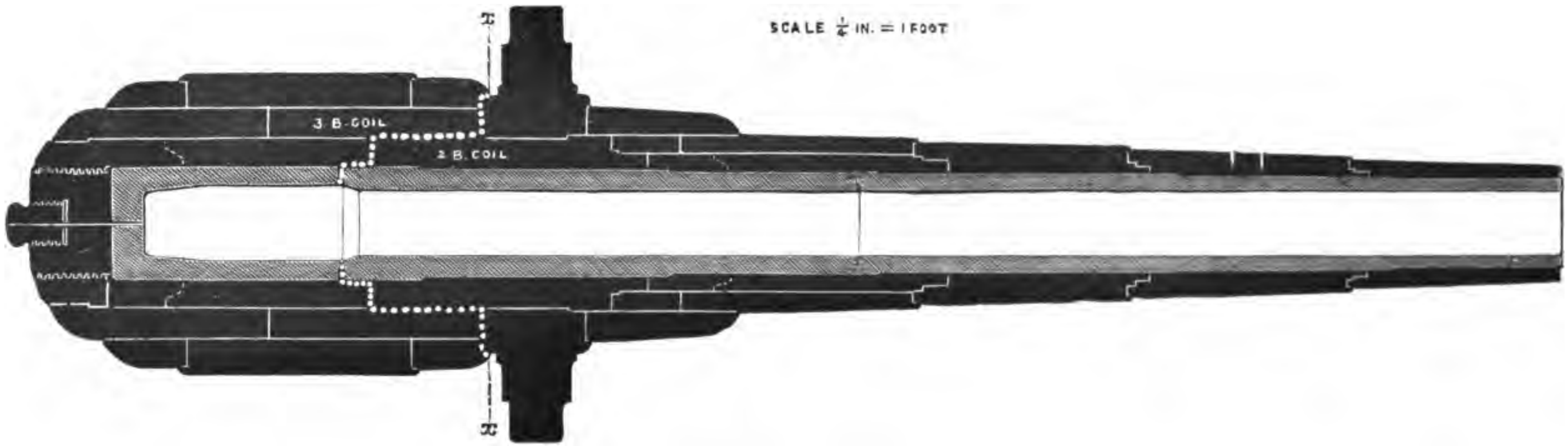
And also some smaller rifled pieces for boats and small craft, and some heavy smooth-bores, which latter, however, are being replaced by those above enumerated. To complete the list given above, the 18-inch Armstrong gun, well known under the name of the 100-ton gun, should be added. The fleet is armed, as will be seen from the above enumeration, with heavy muzzle-loaders; but there are some rifled breech-loaders carried by despatch vessels and boats, and by armourclads on their upper decks. With the exception of the 100-ton gun the muzzle-loaders resemble those of the English service too much to need any special description. The 8-inch Italian gun, however, differs from the 8-inch English gun by its rifling being on the 'shunt' system and uniform; and it is somewhat shorter and lighter than the corresponding Woolwich gun.

100-ton gun. The idea of acquiring the 100-ton gun dates from the year 1873, and is due to Admiral St. Bon, then Minister of Marine, and to Commander Albini, Director-General of Ordnance and Torpedoes. The gun consists of an inner steel tube in two lengths, surrounded by successive layers of wrought-iron coiled cylinders. There are ten of these coils, six of which are distributed over the rear half of the gun, the remaining four being placed singly around the foremost portion of the steel barrel. Instead of a very few thick coils, as used in the Fraser system, it will be seen that a comparatively large number of moderately thick coils are employed in the Armstrong construction. For a distance of thirteen feet from the rear end the tube is enveloped by a coil seven inches thick; over this, for a length of 9½ feet, is a coil eight inches thick. Then comes the trunnion coil, which is eleven inches thick. Beyond this is a tapered coil, which has an average thickness of 6½ inches. Outside the second long coil is another to the rear, nine inches in thickness and 5½ feet in length, which reaches to the trunnion coil.

Thus the breech-portion is enveloped in three coils. The extreme length of the gun is 32 ft. 10½ in. The rifling consists of twenty-seven grooves, with a twist beginning at one turn in 150 calibres increasing to one turn in fifty near the muzzle, after which it is uniform. Like all muzzle-loading guns of greater length than the 35-ton Woolwich gun, the operations of sponging and loading have

Fig. 63.

SCALE $\frac{1}{4}$ IN. = 1 FOOT



THE 100-TON M.L. GUN.

to be performed with the aid of machinery. In the Italian, as well as in the British navy, this machinery is on the hydraulic principle. The battering shell of the 100-ton gun is a hollow chilled cast-iron projectile on the Palliser system. It has no studs, and is rotated by the gas-check of the Elswick Company, which is a copper saucer fitting over the base with projections to take the grooves of the rifling. The head of this shell is somewhat more pointed than that of the corresponding projectiles in the British service. To facilitate manufacture a device has been resorted to, which has also been adopted in the manufacture of the more recent Woolwich projectiles of chilled iron. The cylindrical portion is of a somewhat less diameter than the shoulders, which only have to be turned down to gauge in the lathe. The Italian Government has of late paid much attention to the improvement of the projectiles for this gun. They are manufactured from Gregorini metal, which can be procured in Italy. This cast-iron is considered to be of very good quality, and from it the principal portion of the very large breech-loading rifled guns for coast batteries are being constructed.

The performances of this gun, and the effect produced by its projectiles against armour, may be briefly noticed. When fired for trial it was placed on a pontoon, which was towed out into position in the bay. With a projectile weighing 2,000 lbs., and a charge of 300 lbs. of powder, a muzzle velocity of 1,374 feet a second was obtained, which gave to the shot a total energy of 27,656 foot-tons. When the charge was increased to 340 lbs. the muzzle velocity was raised to 1,475 feet a second, and the total energy to 30,163 foot-tons. A subsequent increase of the charge to 375 lbs. of powder gave a result of 1,543 feet muzzle velocity, and 33,000 foot-tons energy. The powder used was of the cubical Waltham Abbey description, each grain being a cube of an inch and a half a side. In a second series of experiments the powder made at Fossano, in Italy, expressly for the gun, and named 'progressive,' was used. The merit of this explosive is that, when fired in quantities considerably larger than could be employed with other powders, it gives a higher velocity to the shot, and at the same time brings a less strain upon the gun. 'Taking the average of the rounds,' says Mr. King, 'it is seen that the Fossano powder gave 982½ foot-tons more energy than the English, with a reduction of four tons in the pressure on the interior surface of the gun.'

The 100-ton guns since manufactured at Elswick for the armament of the turret ships 'Duilio' and 'Dandolo' are capable of producing better results than that just spoken of. Some important

modifications have been introduced into their designs. Instead of a uniform bore of 17 inches, as in the first piece, the newer guns have a calibre of 17¾ inches and a powder-chamber two inches more in diameter. These guns will be fired with a charge of powder of more than 500 lbs., and a projectile of nearly a ton. The external shape is slightly different; the change made has the effect of throwing a greater portion of the metal forward in the breech-portion, so as to strengthen the gun somewhat in advance of the powder-chamber. The object of this is to suit the conditions existing when the progressive powder is fired; it being a feature of slow-burning powders to throw the pressure forward, as it were, in the bore. Sir William Armstrong's firm are making for the Italian Government, apparently for the new ships 'Italia' and 'Lepanto' now building, eight still newer 100-ton guns, which are to be capable of being loaded either at the breech or at the muzzle.

Mr. King, of the United States Navy, in a communication to the *New York Army and Navy Journal*, says, on the authority of Mr. G. W. Rendel, of Elswick, that a chambered gun fired with 551 lbs. of Fossano powder, and a projectile of 2,000 lbs. weight, indicated a muzzle velocity of 1,700 feet a second, the total energy being 40,000 foot-tons; and surpassing anything yet achieved with heavy ordnance. In consequence of the bursting of one of these guns on board the 'Duilio,' an account of which will be given on a subsequent page, the charge has been reduced to 507 lbs.

Fossano powder.

The Italian navy, which has obtained its guns from English makers, has also procured the same 'pebble' powder which is used with the guns of the latter nation. The Armstrong guns are still loaded with English 'pebble' powder in the Italian fleet, though it will soon be superseded by the home-made powders from the Fossano works. This powder factory is situated about three-quarters of a mile from the town of Fossano, in the district of Cuneo, in the north-west of Italy. It stands in the middle of a tract watered by the Stura and Mellea canals, which furnish the power necessary for the machinery of the establishment. The 'progressive' powder was devised by Colonel Quaglia, the director of the factory, and his assistant, Captain de Maria. As in the manufacture of other powders, a cake of a certain density is first made. This is broken up into small irregular grains, which are mixed with a quantity of fine grain powder, and the whole is pressed a second time to form a new cake. This cake is also broken up into regular pieces of a density different to that of the first. These cakes are composed of small masses of high density scattered about the conglomerate powder of lower

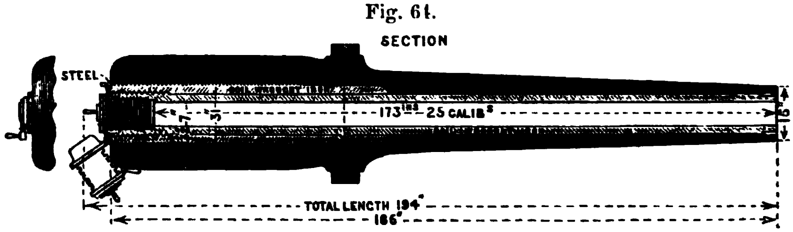
density, 'like raisins in a plum-pudding.' The result of this mode of manufacture is that towards the completion of the combustion of a cartridge of 'progressive' powder, a quantity of gas is formed much larger than that developed at the first ignition, which constitutes what has been called the 'progressiveness' of the explosion. The pressure on the projectile tending to propel it forward is thus maintained during its course through the bore, and is possibly even increased whilst it is moving away. A species of powder, not unlike the English P^2, is also manufactured at Fossano, and is called 'parallelopipedic.'

In the Austrian fleet the two systems—steel breech-loading guns of the Krupp pattern reinforced with exterior rings, and Armstrong muzzle-loaders—are employed. But the latter are being given up, and are only used for arming the older vessels. Some rifled guns of cast-iron or bronze, loading at the breech, on the Wahrendorf system, are still, or were till lately, mounted on board some ships. The boat-guns of the Austrian service are bronze muzzle-loaders. Light guns, up to a calibre of about six inches, have been made on the plan of General Uchatius of hardened bronze, and have proved so successful that at one time it was in contemplation to extend the use of this material to the manufacture of pieces large enough to rank amongst the armour-piercing ordnance of the fleet. These guns are cast hollow, and a mandril is forced through them till the bore is enlarged nearly to the size it is intended to be finally. The Krupp guns, which will soon form the armament of all, or at least of the heavier, ironclads of Austria, are similar in all respects to the guns of corresponding size carried by German ships of war. The Austrian cast-iron projectiles are obtained from the works of Ritter and Co., a private firm, established at Fridau. It is said that chilled battering shell is to be given up in favour of projectiles of cast steel. Austrian naval guns.

The guns of the American navy exhibit a striking contrast to those of European services. The United States ships are still armed with cast-iron smooth bores; and, although a movement in advance has been begun, rifled guns have only as yet been adopted in the case of pieces of comparatively small calibre. It is stated upon good authority that the cast-iron used for constructing guns in America is amongst the strongest and best in the world. It is smelted in small charcoal furnaces with cold or moderately hot blast, and from pure, rich, soft limonites. The larger guns are cast hollow. Hitherto the smooth-bore guns of the American navy have been divided into two classes—shell guns and shot guns. The former are designated by their calibre in inches; the latter by the weight in pounds of American naval guns.

their spherical shot. There are shell guns, for example, of 8, 9, 10, 11, and 15 inches, and 32- and 64-pdrs. Those of the later pattern are called Dahlgren guns, from an admiral to whom the improvements contained in it are due. Admiral Dahlgren's method of manufacture consists in casting the gun of a thickness considerably greater than it retains in its final shape, in thus employing a larger quantity of metal than is absolutely necessary to make it merely of the size determined on, in reheating this mass after cooling, and in turning down the excess of metal in order to bring the gun to its proper dimensions. Externally these guns are perfectly smooth, without angles or projections, and the thickness decreases progressively from the breech to the muzzle in proportion to the pressures in the interior, which the walls have to support, when the charge is fired. The chamber is conical and rounded at the bottom, and the vent is inclined to the axis. The 15-inch smooth-bore, whilst very inferior to a 10-inch rifled gun in range and penetrating power against stout

Fig. 64.



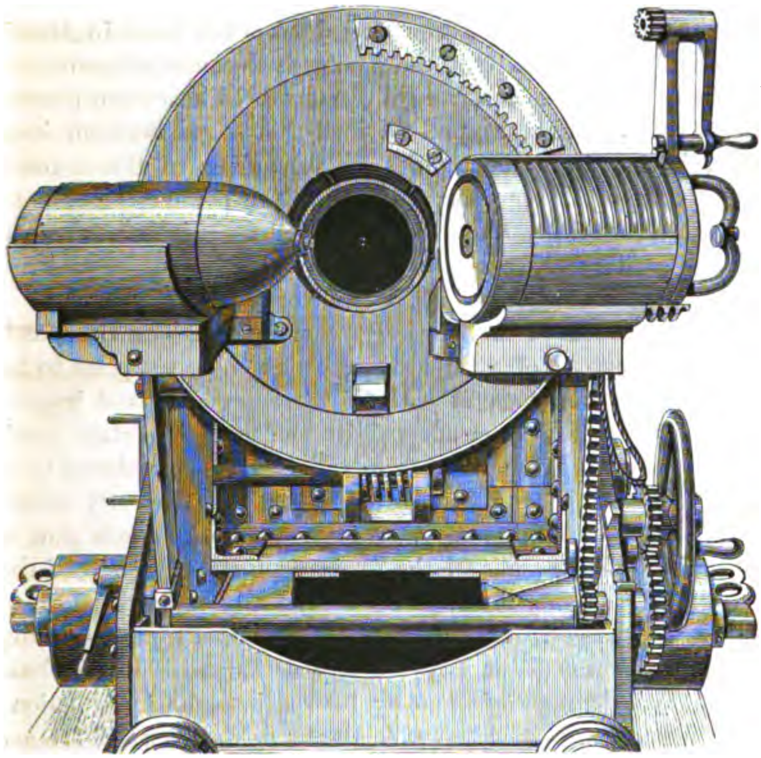
SECTION OF AMERICAN PALLISER GUN.

armour, is by no means an insignificant weapon. This gun was designed more than twenty years ago, and was intended to fire a 350-lb. shell with a 50-lb. charge of powder. At present it fires a solid shot weighing 450 lbs. and a service charge of 100 lbs. of powder. The muzzle velocity with the heavier charge is about 1,600 feet a second, with very moderate pressures in the bore. Should the general adoption of steel-faced armour cause a recurrence to the 'racking' instead of the 'punching' mode of attack—as some think may be the case—such a gun as this may continue to be formidable.

Till very recently the only rifled guns carried by the ships of the United States were on the Parrott system, 100-pdrs., 60-pdrs., and 30-pdrs. of cast-iron, strengthened by a wrought-iron jacket over the breech portion. Boat-guns are made of bronze and rifled on Dahlgren's system. Both of these classes are muzzle-loaders. Some Parrott 100-pdrs. have been converted into breech-loaders. The grooves of the Parrott and converted guns are of the plain rectangular

type, the number being uneven so as to bring a land opposite to a groove; lands and grooves are equal in width, and the latter are $\frac{1}{100}$th of an inch deep. The twist is increasing. It is not easy to give an exact account of the armament of the American navy, owing to its being at present in a state of transition. The principle of substituting rifled breech-loaders for smooth-bore muzzle-loaders has, however, been determined on, and some ships are already armed with Dahlgrens converted on the Palliser system, and having the

Fig. 65.



FRENCH SYSTEM OF CLOSING THE BREECH, AS FITTED TO CONVERTED AMERICAN GUNS.

French breech-closing apparatus. The 11-inch smooth-bore, weighing about nine tons, has been turned into an 8-inch rifle, firing a projectile of 188 lbs. One of these has fired 750 rounds, and is stated by Commodore Jeffers to have stood the test perfectly. Experiments are still in progress. The projectiles are rotated by a ring near the base, called the Butler gas-check, from its inventor.

Officers of the United States preceded those of other countries in their investigations into the action of fired gunpowder, and can American gunpowder.

claim to have marked out the paths which all subsequent students of what may be called the science of that explosive have followed. Without the invention of the Rodman pressure-gauge it would have been hardly possible for our knowledge of the effect of igniting a charge of gunpowder in a gun to have advanced to the point, to which it has now been carried by our fellow-countrymen, Professor Abel and Captain A. Noble. Major Mordecai's researches, made nearly forty years ago, laid the foundations of the present system of manufacturing gunpowders of very large grain. Experiments, with the view of determining the best form of powder for use with the newly converted guns, have been carried out of late years in America. It appears to be settled that the powder is to consist of grains, each of which is a large pellet formed of two truncated hexagonal pyramids base to base. They are pressed into this shape between bronze plates, having in them cavities corresponding to the truncated pyramids arranged honeycomb fashion. The powder comes out in slabs, which are easily broken up into pellets. It is said to be equal to the prismatic powder used in Germany, and is cheaper and more convenient to manufacture. It is called 'hexagonal' powder.

Armament of the Russian navy.

The armament of the Russian fleet was for a long time, and is still to some extent, of a varied nature. The object appears to have been to take advantage of each of the several kinds of improved weapons, which had been adopted by the more important foreign maritime powers. Guns were formerly obtained from abroad to arm ships, but now they are manufactured in Russia. The early monitors belonging to the Baltic force were built on the American plan, and carried smooth-bore guns of the American pattern. Some of these are still retained, but they are being gradually replaced by breech-loading rifled pieces. These were at first procured from Herr Krupp, but they are now made on a system very similar to his at the Obukoff gun factory. Reasons of economy have led to the introduction of cast-iron guns, with steel hoops, on the French plan, which are made in the government of Perm. With the exception of some 15-inch smooth-bores, still found on board certain monitors, and in certain coast-batteries, the heavy naval ordnance consists only of hooped steel guns, resembling those of Krupp. The heavy smooth-bores are being withdrawn in favour of 11-inch or 12-inch guns of the latter kind, fifty or sixty of the new pieces being mounted annually. Russian ships carry the following guns:—

30·5 c/m. (12-inch)	gun	with three	rows	of hoops.
28 c/m. (11-inch)	,,	,,		,,
23 c/m. (9-inch)	,,	two		,,
20 c/m. (8-inch)	,,	one		,,
15 c/m. (6-inch)	,,	,,		,,

The first two are intended to arm turret-vessels; the 8-inch and 9-inch are for broadside ships, while the 6-inch pieces are reserved for unarmoured cruisers. Some of the same calibre as these last, but of improved construction, and throwing shot with a very high velocity, are mounted on board the new corvettes of the 'Rasboynik' class. For some time the Russian authorities have paid attention to the necessity of having guns of considerable length; and in many ships are to be found pieces the bore of which is twenty calibres long.

The steel guns are made at the Obukoff works at Alexandrovski, about nine miles from St. Petersburg, on the left bank of the Neva. It was established in 1863, and employs 1,200 workmen. It has twenty boring machines, and can turn out annually forty guns of from 8-inch to 12-inch calibre. This number can be increased to sixty, and probably has already been so augmented. Connected with the gun works is a small-arms' factory. The mode of making the steel guns is evidently copied from that followed at Essen. The iron is first forged into slabs of about 130 lbs. weight, and these are drawn down under the hammer into bars 1¼ inch in thickness. The bars are then cut into small pieces, and placed in crucibles, where they are melted either by coke or in a gas furnace. The ingot is made twice the weight required in the finished article. The ingot is heated afterwards in a reverberatory furnace. The inner tube of a gun is finished under a 100-ton hammer, the rings or hoops under one much lighter. The forging of an inner tube for a 9-inch gun is completed in about sixteen hours in six heats. As soon as it is finished it is turned down. It is then bored, and afterwards reheated in a charcoal furnace. The tube is tempered in oil, and afterwards prepared to receive the hoops. For this purpose it is put upright, and the hoops, which have been previously set in a bath of lead, are heated and placed over it. The rifling is next proceeded with. A 12-inch gun requires six months to complete it. Those of this class for the turrets of the 'Peter the Great' cost 13,280*l.* apiece. The total length of one of these guns is twenty feet. The breech-closing arrangement is very similar to that of the Krupp guns. The gun is rifled with thirty-six grooves, with a uniform twist. Its battering charge is 121 lbs. of slow-burning prismatic powder. Lead-coated projectiles have hitherto been used, but it is probable that they will be given up for those fitted with copper bands. Chilled battering shell, and shell with steel points, are fired from these heavy guns, but cast-steel is being tried as a material of which to make armour-piercing projectiles. As it has been already observed, with the view of introducing a more economical plan of constructing guns, the Russian

Government has decided to try some formed of a cast-iron body, strengthened by steel hoops, on a method like that employed in France. Experimental pieces have been cast at the Perm foundry, and the results have been thought satisfactory enough to warrant more being done in the same direction. A 9-inch gun on this system, weighing 18¾ tons, stood the firing of 500 rounds before the addition of the strengthening hoops. When two rows of these were added it fired 600 rounds more. The gunpowder used in Russia is the prismatic, which has already been described. It is, indeed, to that country that we owe the introduction of this particular kind of powder, which was tried there many years before its adoption elsewhere.

Mitrailleurs, or machine guns.

While changes are being made so rapidly in the ordnance carried by the ships of different navies, and in the powder charges and projectiles of those guns that are still retained, that it becomes difficult, if not impossible, to give an exact account of the power of any particular piece, weapons of a new description are also being added to the armament of fleets. *Mitrailleurs*, or machine-guns, are now to be found in almost every navy in the world. These apparently occupy an intermediate place between rifled small arms and rifled cannon of small calibre. There are several kinds of these new weapons, which differ considerably from each other in mode of construction and system of working. In general terms they may be described as weapons intended to fire bullets of small, or at least of moderate weight, in quick succession and for a lengthened period of time; the actual loading, firing, and extracting of the empty cartridge-case, and in some cases the pointing of the gun, being effected by machinery contained within the general structure of the weapon set in motion by the person who takes aim. A machine-gun, or *mitrailleur*, is, in fact, a combination of several guns of small size, aimed and fired by a single person. Under certain circumstances such a weapon would be very likely to prove exceedingly useful to a ship of war. For some years past it has been customary to mount some kind of machine in a vessel's tops to clear an enemy's decks of men, in action, at moderate ranges. More lately it has been sought, by supplying several of them to individual vessels, to give the latter additional means of protecting themselves against torpedo-boats, a form of attack to which ships of war operating near an enemy's coast will be frequently exposed. The best-known machine guns for naval purposes are the Gatling, Nordenfelt, Hotchkiss, and Gardner.

Gatling.

The two former have already been mounted on board some British ships, as well as those of other powers. The Hotchkiss gun

is largely used by the French navy, and, to some extent, by that of the United States. The Gatling gun, since it was first introduced, has been considerably modified in its details by its inventor, Dr. R. J. Gatling, an American. Like all other guns, its size and power depend on the dimensions of the bore, and there are several sizes. The present gun has ten barrels, each eighteen inches long, and each having its own lock. The barrels and locks revolve together. A forward motion places the cartridges in the chambers of the barrel and closes the breech; a backward motion extracts the empty cartridge-cases after firing, these cases being thrown out to the left of the gun. As long as the gun is revolved from left to right and fed with cartridges, the several operations of loading, firing, and extracting are carried on uniformly and continuously. An arrangement in the pieces of smaller calibre can also be thrown into gear, if desired, by which the pointing of the gun is continuously altered from left to right, and back again, so that a considerable front may be swept by its fire, the change of direction being brought about by the turning of the same handle that effects the discharge. A feed-case stands vertically over the centre of the lock-chamber, that the cartridges may fall directly into the receivers. Each case contains forty cartridges, and the cases fit into a 'hopper' communicating with the chambers. As soon as one case is empty another takes its place. This gun is said to have been fired at the rate of 1,000 rounds a minute; the ordinary rate of firing is about 700 rounds a minute. Fired deliberately at a target 19 feet long and 11 feet high, 1,000 yards distant, 665 hits were made out of 1,000 shots. In some recent practice shots are stated to have been fired at the rate of 44 a second.

Nordenfelt. In the Nordenfelt gun the barrels do not revolve, but are placed side by side horizontally. The firing mechanism of the piece is actuated by a lever, which is moved to and fro by the right hand of the person aiming. If this lever be worked rapidly a nearly simultaneous fire issues from the four barrels; and a continuous working in this way would result in a rapid series of small volleys. The lever can be also moved so as to maintain a continuous fire of single shots. A feed-case is placed erect over the gun, from which the cartridges drop through on to a carrier, whence they are pushed into the barrels. There are several sizes of this gun, the largest of which has two barrels. The projectiles are made of steel.

Hotchkiss. The Hotchkiss 'revolving cannon' consists of five barrels, grouped round a common axis, which are revolved in front of a solid immovable breech-block. This has in one part an opening through

which the cartridges are introduced, and another through which the cases are extracted, whilst the cartridges are discharged singly. The turning of a crank causes the loading, firing, and extraction of the empty cartridge-cases. The breech is closed tight by the metallic cartridge. Should rapid firing be desirable, the gun is supplied with feed-cases, containing ten cartridges each. The cartridges descend along a trough into the receiver. If the trough be supplied with single cartridges, about 40 rounds a minute may be fired; if with feed-cases, from 60 to 80. Six different patterns of the revolving cannon have been constructed. Three of these are specially intended for naval service. They are:—

1. The light 37 millimetre (1½-inch) gun, firing an explosive shell of 1 lb., and a steel shot of 1½ lb.

2. The 47 millimetre (1¾-inch) naval gun. The weight of the explosive shell being 2½ lbs., and that of the steel cored shot the same. This gun is similar in construction to the foregoing; it is also mounted on a swivel, and is trained and fired from the shoulder by one man, an arrangement somewhat resembling a musket-butt being attached for the purpose.

3. The 53 millimetre (2-inch) revolving cannon, with an explosive shell weighing about 4 lbs.

Experiments made with Mr. Hotchkiss's gun in America, England, and Austria, are said to show that its projectile is capable of penetrating the steel plating of torpedo-vessels of the 'Lightning' class at a range of 2,700 yards when hitting direct, or about 2,000 yards if hitting within an angle of 30°. The Thornycroft steam torpedo-boats, when running end on towards the gun, and struck at an oblique angle up to 70°, are asserted to have been completely perforated at ranges within 540 yards. The explosive shells are said to burst as they enter the hull, the fragments having sufficient force to damage the bulkheads and machinery. Within a range of 750 yards, we are told that the steel shot from this gun will perforate the boiler, after having passed through the side of a torpedo-vessel, struck at any angle of obliquity up to 35°. The steel shot will penetrate a steel plate an inch thick at rather more than 200 yards. A large number of these guns have been made for the French navy, and they have also been introduced into that of Russia.

A series of trials between the five-barrelled Nordenfelt machine gun and the Hotchkiss revolving cannon were concluded at Portsmouth on May 13, 1880. The accuracy and penetrating powers of the two weapons had been previously tested, and found to be practically the same. The last experiments were to ascertain if the Hotch-

kiss gun, fired from a ship under way, was better adapted for riddling and disabling a torpedo-boat also under steam than the Nordenfelt, which is already in use on board some of the British ships-of-war. The two machine guns were mounted on the forecastle of the 'Medway' gunboat; the targets consisted of four full-sized models of second-class torpedo-boats, with dummy machinery inside, floating upon rafts. The 'Medway,' starting at 1,500 yards distance, advanced towards the torpedo-boats, each gun firing all the way until close up; and in two instances the range was shortened to 600 yards. The attacks were directed sometimes against the broadside, and at other times against the bows of the targets. At a distance of a mile the targets, end on, presented a very small object. The Nordenfelt riddled the torpedo-boat through and through, every third shot scoring. Five of the shots hit the models of the piston-rods in the interior, any one of which, it was thought, might in actual hostilities have disabled the boat. The Hotchkiss gun also made very excellent practice. In the last two runs this gun made 90 hits out of 153. The explosive shell had a bursting charge of rather more than three-quarters of an ounce of powder; the fragments are said to have flown all over the small space inside the boat, many of them passing through the opposite side. The bursting of these shells at one time appeared to fill the torpedo-boat target with smoke.

Gardner. The Gardner gun is different from any of the foregoing. It has usually a single barrel, though in some patterns a second barrel has been fitted. Rapidity of fire is secured by the nature of the mechanism, and not by rotation of barrels or chambers. The firing arrangement is simple, and depends but little upon the action of springs. A long feed-trough is placed erect on the gun, down which the cartridges slip into the tray and thence enter the chamber. This gun has not yet been made of very large size.

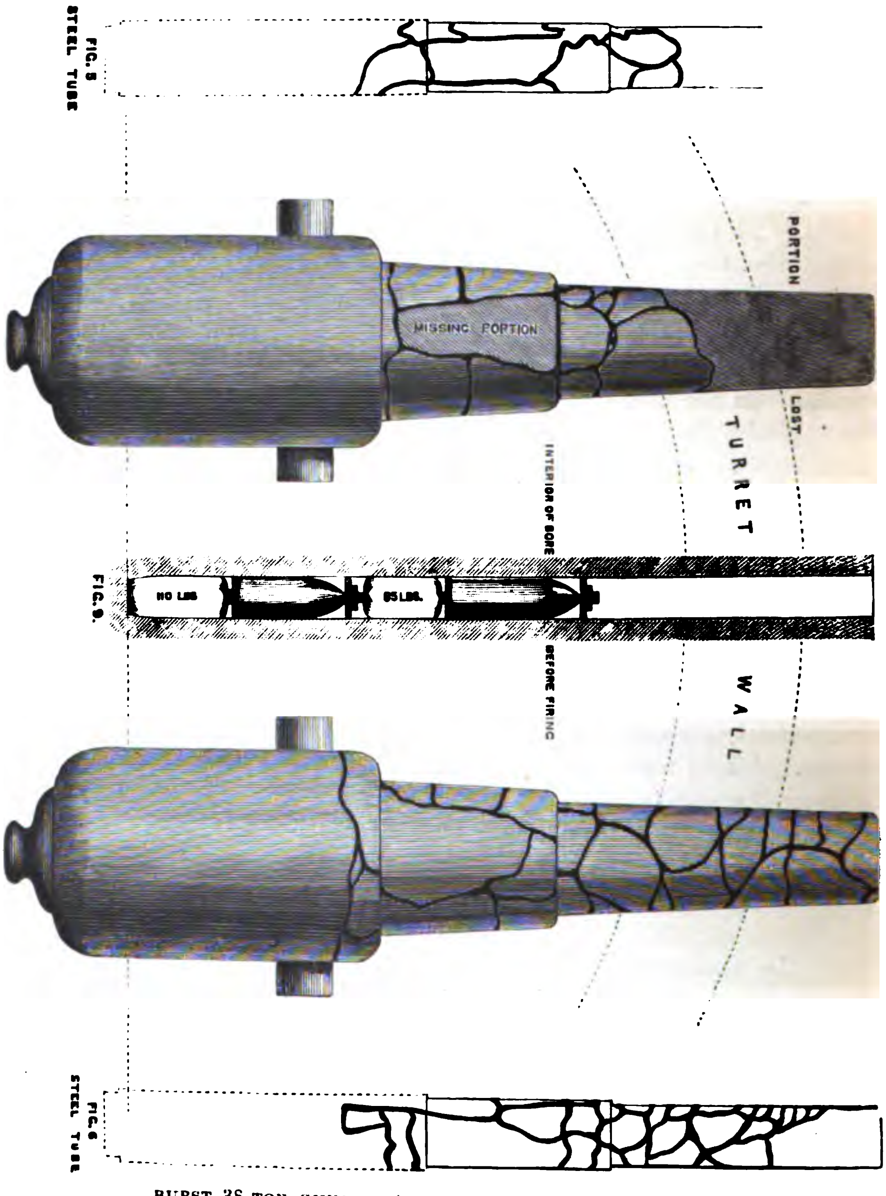
II.

Some recent events in the history of very heavy guns. In the unsettled state of many questions of gunnery to which reference has already been made, the history of some recent occurrences, when guns of great size were fired, is particularly interesting. At present we are, perhaps, only in a position to say that these events teach the necessity of extreme caution in attempts to solve gunnery problems.

Accident on board H.M.S. 'Thunderer.' The accident on board the 'Thunderer' has aroused grave misgivings as to the advantage of introducing very heavy guns into the armaments of ships. The fore-turret of the 'Thunderer' was armed

with two 38-ton guns of 12-inch calibre; the bores having been specially kept to this size, instead of the usual twelve and a half inches of ordnance of that weight, in order that the same projectiles might be used

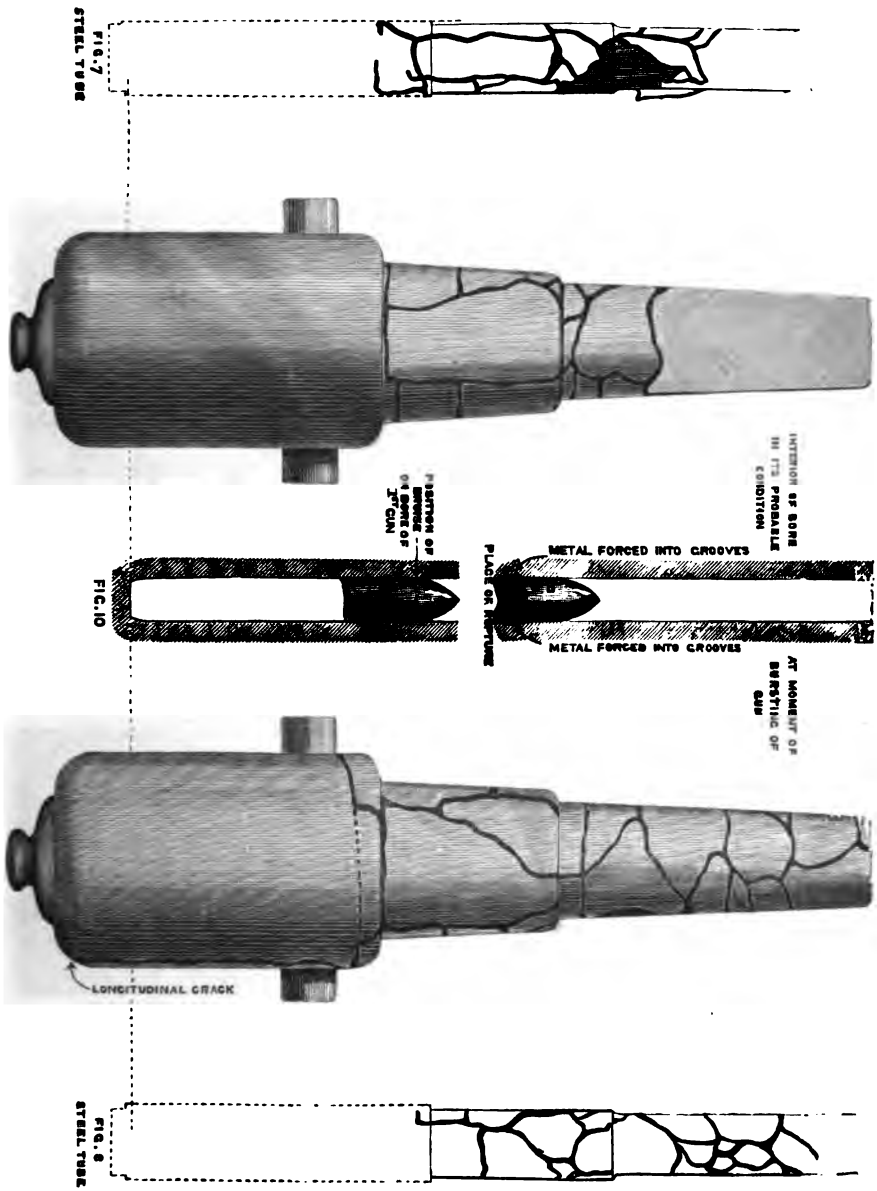
Figs. 66, 67, 68, 69, and 70.



BURST 38-TON GUNS OF 'THUNDERER' (THE LEFT GUN BURST BY ACCIDENT ON BOARD).

for the guns in the fore-turret, and for those weighing 35 tons in the after-turret. The supply of ammunition was thereby much simplified.

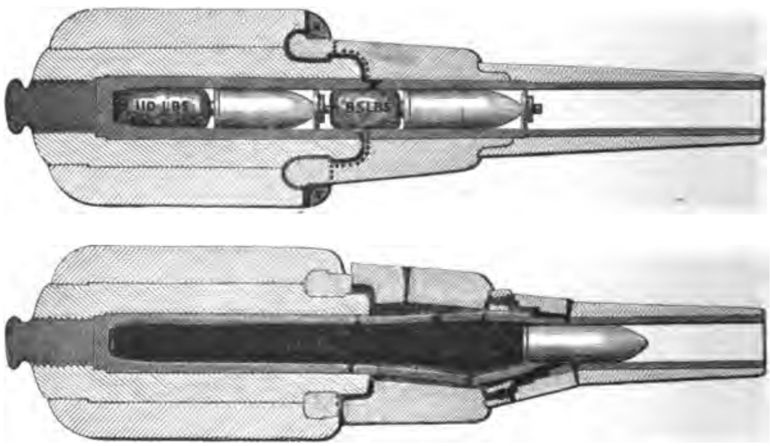
Figs. 71, 72, 73, 74, and 75.



The length of the 38-ton guns rendered it necessary to have a special contrivance for loading them when their muzzles were outside the

turret. The turret is provided with two ports above the level of the breastwork, or upper deck, through which the muzzles of the guns are run out to be fired. Immediately below these two ports are two other ports, or, more strictly speaking, tubes made through the thickness of the turret in a direction inclining downwards, so that when the guns are depressed at the muzzle these tubes shall form prolongations of the bore. The lower ends of the inclined tubes are immediately below the upper deck, and open into the battery deck next below it. From this battery deck the guns are loaded by pushing the cartridge, the projectile, and the wad up the tube and the inclined bore. Two sets of hydraulic-loading apparatus were provided, placed respectively at an angle of about 33° on each side of the midship line of the

Figs. 76 and 77.



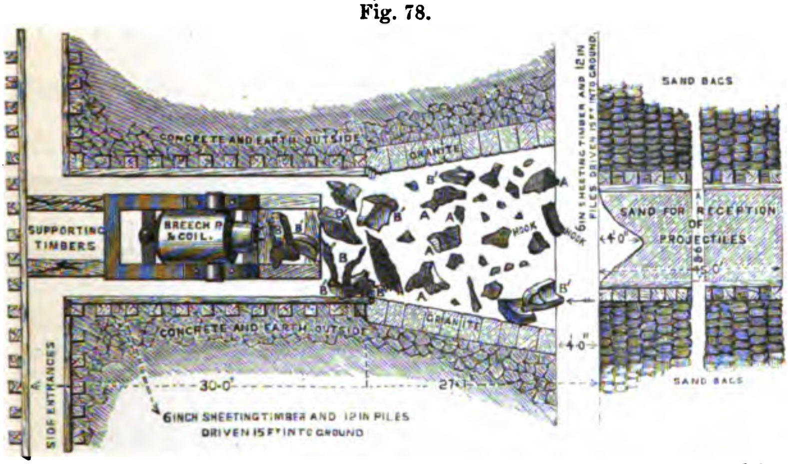
SECTIONS OF THE TWO 'THUNDERER'S' GUNS (SHOWING PROBABLE MODE OF BURSTING).

vessel and abaft the turret. The elevating, firing, and running in and out of the guns, are effected by men inside the turret, the sponging and loading by men outside it and separated from the former. On the morning of January 2, 1879, the 'Thunderer' was at target practice. The two guns were each loaded with a battering charge of 110 lbs. of powder and an empty Palliser shell, *papier-mâché* disc wads being used. It was intended to deliver an 'electric broadside.' On the firing key being depressed to fire this broadside, it was afterwards believed that the left gun in the fore-turret missed fire. After the electric broadside the guns were ordered to be loaded and fired with 85 lbs. of powder and empty common shell. The left gun when fired burst explosively, killing the officer of the turret and eight of the nine men within it, but leaving surviving, though much injured, one man. One officer and one man on the battery deck outside were

killed and thirty-four other men were more or less injured. A Committee appointed to enquire into the cause of the accident unanimously reported that the members had come to the conclusion that the first charge had not been fired, that the second was rammed home upon it, and the gun was fired when thus doubly loaded.

In consequence of a recommendation contained in the Committee's report, the sister gun was sent to England, and after a series of other experiments of less importance, was doubly loaded and fired in a cell specially constructed to receive it, at the proof butts in the Royal Arsenal at Woolwich, on February 3, 1880. The two charges and projectiles were rammed hard home. In this condition the piece was fired. The sound of the explosion was low and rather dull, so that it would not have suggested anything unusual to a listener. No double

Fig. 78.



THE 'THUNDERER'S' GUN (SHOWING THE BURSTING CELL AND PIECES OF GUN AFTER EXPLOSION AT WOOLWICH).

sound was audible. On entering the cell it was found that the gun had burst explosively about the same place as its predecessor.

'The gun had given way,' says a writer in *Iron*, 'under conditions of loading similar to those under which the Committee concluded the sister gun burst with such fatal consequences some thirteen months before, and the fragments of both guns present lines of fracture very closely analogous.'[1]

The 'Thunderer' gun which burst was a 38-ton gun of 12-inch calibre; all existing 38-ton guns are of 12½-inch calibre. There was no sign of weakness of welding in the fragments of the gun burst at Woolwich.

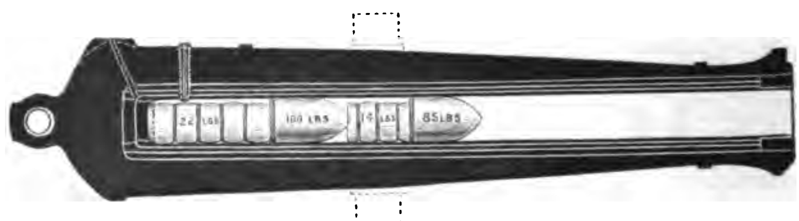
On March 23, 1880, Sir William Palliser carried out some double-

[1] See the figs. on pp. 82, 83, which show the nature of the fractures of each gun.

Palliser double-loading experiments.

loading experiments at Erith, his object being, as he expressed it, 'to ascertain the ultimate strength of a gun lined with a coiled barrel 7 inches in bore, and barely 3 inches thick; and, in the event of the gun bursting, to see whether or not it explodes with violence.' An able report of these experiments was given in the *Engineer* of March 5. The gun tried was a 7-inch rifled gun of 95 cwt., converted from a 10-inch shell-gun of 84 cwt. by means of a coiled wrought-iron barrel inserted in it. The piece was a veteran, the outer casing of it having been fired in the trenches at Sebastopol in 1855, where it had been struck and cut by a shell in the muzzle. There were three inner tubes. The outer of the three had been placed originally in a 68-pounder, with a steel tube inside it. This steel tube had split in firing, and had been bored out, and the second coil had been inserted. The 68-pounder thus lined had been severely tested, the breech being blown out at the 136th round. The double coil was then removed

Fig. 79.



PALLISER'S GUN (EXPERIMENTS SHOWING POSITION OF CHARGES WHEN DOUBLE-LOADED).

and entered as a lining to the 10-inch gun employed in the present experiments, being first bored out to 8 inches and rifled. In this condition it was very severely tried. It was next bored up to 8½ inches, and lined with a third tube, bringing the calibre up to seven inches. The powder used in the experiments noticed was pebble, or P. the same as that with which the burst 38-ton guns were loaded; and it has been objected that the experiments should have been conducted with powder of a smaller grain to render comparison with the effect on those guns of value. The 95-cwt. gun being one-eighth the weight of that of the 38-ton, the first round was fired with charges one-eighth the weight of those which burst the last-mentioned gun. Solid cast-iron studded projectiles were used, except the rear shot in the first and second charges, in which the studs had to be omitted to allow the projectiles to be rammed close home against the powder. The following statement shows the weight of powder and shot in each of the five rounds fired:—

	Rear charge				Front charge			
	lbs.	oz.		lbs.	lbs.	oz.		lbs.
Round 1	13	0	powder	88 shot	10	10	powder	75 shot
„ 2	16	0	„	100 „	11	0	„	85 „
„ 3	18	0	„	100 „	12	0	„	85 „
„ 4	22	10	„	100 „	13	0	„	85 „
„ 5	22	0	„	100 „	14	0	„	85 „

Thus in the last round there were in all 36 lbs. of powder and 185 lbs. of shot. The length occupied by the last double charge was 55 inches, or rather more than one-half the length of the bore. The pressure on the sides of the latter was shown to be considerable by the expansions, which were measured after each round. The writer already quoted says:—'The gun has stood admirably. . . . It may require explanation how it is possible for this gun to have stood the tests imposed on it at all. First, then, it must be remembered that coil tubes entered into a cast-iron gun by the muzzle must, of necessity, be thick, and therefore as strong at the muzzle end as at the breech end of the bore. Such tubes, being strong enough for the work falling on them at the breech, must have a great marginal strength forward—in fact, would be as well able to stand a charge fired half-way up as at the bottom of the bore. . . . There remains still the violent and sudden action due to the position of the front charge between the two shots. This action, in the case of the 38-ton gun, was apparently so violent as not to resemble the normal explosion of powder. This strain Sir William Palliser's gun, being a converted and old weapon, has borne wonderfully well, at all events up to the fourth round, and deserves very high praise for it. As the experiment stands, Sir William Palliser has made out a good case for coiled inner tubes of iron. But it must not be forgotten that the analogy between large and small guns is comparatively remote.'[1]

Whitworth guns.

Whilst Sir William Armstrong has been engaged in developing the improvements in ordnance already described, Sir Joseph Whitworth has continued his labours upon the principles which he has so long advocated. The distinctive features of the Whitworth and the Woolwich gun were described and illustrated in the following article in *Iron*:—

'Assuming the truth of the remarkable hypothesis of double loading, it so happens that a Whitworth 12-inch muzzle-loading

[1] Since the above was in type, some further 'double-loaded' experiments have been made by Sir W. Palliser, and at length his gun has been burst by them.

Iron or the bursting of the 'Thunderer' 88-ton gun, and on round fired with a Whitworth 35-ton gun.

35-ton gun was nearly three years ago exposed to an accidental test involving a similar strain to that on the "Thunderer" gun—a strain to which it did not yield. The Whitworth gun was one of the four made for the Brazilian Government, constructed entirely of fluid-pressed steel. They are shorter than the regular length, in order to suit the diameter of the turrets in which they are to be placed. Experiments for the purpose of determining the ranges at different degrees of elevation, and of ascertaining the penetration of the projectiles, were made at Gâvre, in France, in consequence of the English Government having refused to allow them to be made at Shoeburyness; and they were conducted by a Commission of French officers, the Brazilian officers being present.

'Forty-nine rounds were fired from the gun with projectiles of various weights, forty-seven rounds being fired for range and velocity, and two rounds for penetration. The following are the chief results, with a comparison of the relative power of the Woolwich 35-ton gun:

	Woolwich	Whitworth
Weight of projectile	700 lbs.	750 lbs.
Bursting charge of shell	10 lbs.	20 lbs.
Initial velocity	1,300 feet	1,365 feet
Velocity at 400 yards	1,256 feet	1,335 feet
Energy at muzzle	8,205 ft.-tons	9,700 ft.-tons
Energy at 400 yards	7,635 ft.-tons	9,261 ft.-tons
Energy per inch of the shot's circumference at muzzle	219 ft.-tons	265 ft.-tons
Ditto at 400 yards	204 ft.-tons	253 ft.-tons
Range at 6° elevation	3,350 yards	3,529 yards
Energy per ton of gun's weight	235 ft.-tons	277 ft.-tons

'The first round fired for penetration was with a flat-headed steel shell, empty, weighing 808 lbs. The shell penetrated the two sets of 8-inch plates forming the front of the target, punching out two discs of its own diameter, which it forced into the backing—composed of oak and wrought-iron plates—to a depth of about 36 inches from the face of the target. The shell remained entire, but was shortened ·6 of an inch, otherwise remaining perfectly sound.

'The second round for penetration was fired with a flat-headed steel shell of 808 lbs. weight, with a bursting charge of 20 lbs. of powder. This projectile passed through the first 8-inch plate, and then exploded, blowing one entire plate off the target; the second set of plates was also deeply indented and broken in several places. Owing to the bursting charge in the shell not having a sufficient thickness of flannel at the front, the explosion took place before the shell had time to penetrate the second plate.

'A third round was fired for penetration with an empty steel shell of 1,180 lbs. weight, with which there was an unfortunate accident. The shell had been filled with sand, but it was taken out by direction of the French officers, with the concurrence of the Brazilian officers, during the temporary absence of the makers' representative (Colonel Dyer, late R.A.), because the addition of the sand made the shell heavier than the projectiles with which the velocities had previously been determined. The shell was therefore fired empty.

'It is probable that in removing the sand from the shell some would lodge in the screw threads; this would be sufficient to prevent the rear plug in the shell from being screwed home up to the collar, and the threads of the screw-plug had thus to bear the whole force of the 120 lbs. of powder, and were consequently stripped off. The stripped threads were picked up afterwards in one piece. The plug itself was forced into the shell, which, owing to the interior being conical, it expanded, and caused the shell to act as a powerful wedge on the bore of the gun, the result being that the metal of the inner tube was bulged and forced forward one-tenth of an inch. It is attributable to the great strength of the metal of which these shells are made that the results described took place, as had the shell been of the usual comparatively weak material, it would have broken up at once under the strain to which it was subjected, and the gun would not have suffered. As it was, the injury was confined entirely to the muzzle end of the inner tube; no other part of the gun except the copper vent was in any way affected. Since the return of the gun from Gâvre the injured tube has been replaced at the request of the Brazilian officers; the gun has also been re-vented, and is now as good as before the accident.

'During the process of boring out the tube a piece was cut from the muzzle end, and a test piece made from it, which gave a strength of 46·7 tons per square inch, with an elongation of 20 per cent. This test proves that the firing of the gun might have been continued with the injured tube. Previous to the tube being bored out, Messrs. Whitworth were anxious that the gun should be fired again, but the Brazilian Government declined to have further experiments.

'Notwithstanding the enormous strain the gun had been subject to, there was not the slightest appearance of powder-gas on the breech screw when it was removed from the gun. The threads were as bright as when first put into the gun, affording ample evidence that the plan of closing the breech is effectual not only under ordinary circumstances, but was also sufficient with the enormous pressure

there must have been when the accident occurred. The pressure of gas in the gun was in effect exploding 120 lbs. of powder in a closed cylinder, for the copper vent was entirely closed up, and the sides of the shell were wedged against the bore of the gun, which checked its passage along the bore until the shell broke up. The amount of this pressure may be imagined from the fact that three inches of the copper vent above the platinum were actually melted away.'

Accident to the 'Duilio' gun.

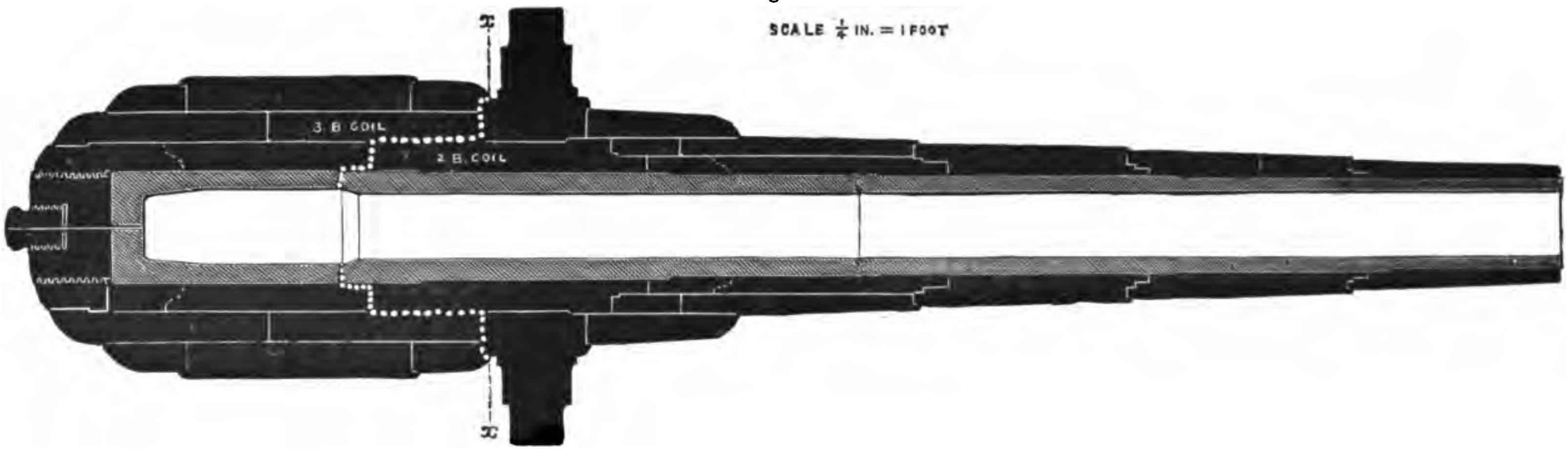
Another case of a gun failing when fired has since occurred, in which it was certain that it had not been doubly loaded. Both of the 38-ton guns which had been so loaded and had burst were unchambered. An accident which happened on board the 'Duilio' at Spezia on March 6, 1880, occurred with a chambered 100-ton gun made by Sir William Armstrong and Co., at Elswick. This gun was not originally designed to be chambered, and the contract entered into by its makers was fulfilled when 440 lbs. of English pebble (P) powder gave to the shot a muzzle velocity of 1,585 feet a second, with a total energy of 34,840 foot-tons, the pressure on the interior of the gun not exceeding 17 tons per square inch. During the trials of the 'Duilio' the guns had been fired repeatedly with charges of 363 lbs., 485 lbs., and 551 lbs. of Fossano powder. On March 6, 1880, the practice was continued. Only one round was fired, and that was from one of the guns in the after-turret, with a powder charge of 551 lbs. and 2,000 lbs. projectile. The gun burst, the steel tube having parted at the base of the truncated cone, which forms the entrance to the chamber. The violence of the explosion was not great. No one was killed, and only two officers and seven men were hurt. A midshipman and one of the men who were close to the gun were severely burned. Five officers standing on the roof of the turret were unhurt. No damage was done to any of the wrought-iron coils surrounding the steel tube. The breech portion was driven backwards against the interior of the turret with sufficient violence to indent the inner steel skin and force the backing against the 22-inch armour plates, so as to open them to a certain extent 'like a pair of folding doors.' The front portion of the gun with the trunnions remained on the carriage.

A committee of officers inquired into the case and reported that there was no fault to be found in the manufacture or material of the gun. The charge, however, was reduced between 40 and 50 lbs.

A writer in the *Engineer* has summed up the lesson to be drawn from the accident on board the 'Duilio' as follows:—'The conclusions of the Italian Commission on the bursting of the "Duilio's" 100-ton gun, of which Admiral St. Bon, Commander-in-Chief, is president,

Fig. 80.

SCALE $\frac{1}{4}$ IN. = 1 FOOT



THE 'DUILIO'S' 100-TON GUN (SHOWING NATURE OF INJURY).

have been now expressed in a report, subject to slight modification according to the results obtained on completing certain tests on samples of steel cut from the tube. This report may be briefly summed up as follows:—Supposing the gun to be made as specified, it was sufficiently strong longitudinally to resist about three times the strain that should fall on it from a battering charge exploding in an ordinary way. Its longitudinal strength is, in fact, greater than its strength in a tangential direction in the proportion of 5 to 4, and is about equal proportionally to that of other guns made on the same system, as well as all their other service guns; and there is no evidence of bad material in the investigations made by the Commission up to the present time. The fact that the tube yielded at the natural line of least resistance, that is, the junction of the cylindrical and conical portions of the chamber, argues that the metal was sound, inasmuch that any flaw would have furnished a weak place of its own. Consequently, the gun being more than sufficiently strong to resist the normal pressure of explosion of a battering charge, the Commission are driven to the conclusion that the charge was fired in such a way as to give rise to an abnormal pressure in the gun, arising, it is suggested, from irregular ignition, such as may occur in firing an untubed charge of great magnitude with an axial vent.

'It may be long before we master the question of the ignition of large charges of powder so as to secure free access for the flame to all parts and a constant trustworthy action of explosion. The Italians content themselves at present by tubing, and reducing their battering charges, and we should not be surprised to hear before long that prismatic powder has at all events temporarily displaced the so-called progressive powder. At Shoeburyness we hear, during the last few weeks, that the new 8-inch breech-loading Elswick gun, fired at five degrees, obtained the remarkable results of a range of over 4,500 yards, with an error in range of about ten yards, and deflection of about four feet. At twelve degrees a range of nearly 7,700 yards, we believe, was obtained with errors of about double the magnitude of those at the shorter range. We at present expect to see the greatest achievements in gunnery in this direction, our vessels being armed with long, powerful and accurate breech-loaders. It will be longer perhaps before we see a 200-ton gun than was at one time expected in either our own Arsenal or that of any other nation.'

During the bombardment of Callao by the Chilians an 8-inch breech-loading Armstrong gun of the new type failed on being fired. The trunnions and trunnion-hoop were left in place, and the remainder of the gun went overboard. Several of the crew were killed

and wounded. It is not as yet satisfactorily settled whether the gun burst, or, as is alleged, merely slipped through its trunnion-hoop.

III.

In contrasting the comparative results attained at Essen and Woolwich, the *Times*, in a leading article of August 6, 1879, criticised sharply the administration of our national gun factory:—'The system pursued at Woolwich has been to place the control of the construction and improvement of artillery under officers who may be assumed to be skilful in the use of guns in warfare, but unskilful in all that relates to the working of metals. The gentlemen so appointed are deprived of the most powerful inducements to the attainment of excellence in manufacture: but they have been allowed to waste money almost without limit in the performance of costly and unnecessary experiments for the determination of points upon which all skilled mechanicians were already agreed. The result is that guns of insufficient length and otherwise faulty construction are still made at Woolwich from coils of iron which are supposed to be welded together, but which, it is well known to all practical men, are in reality not welded at all; and these guns, which are perpetually cracking and splitting, and being sent home for repairs, must inevitably, as soon as they have been fired often enough, or with sufficient charges to overstrain the narrow limits of their resisting power, be shattered to pieces by an amount of powder which they ought to bear with safety. The country is amused with mere bigness of artillery, although bigness which does not exert a corresponding degree of force is only an inconvenience, and although energy or power of penetration is a quality before which size sinks into comparative insignificance. A shell which passed through armour-plating, and exploded afterwards, would be a far more formidable missile than one ten times the size which failed to penetrate; and the projectiles fired from the big guns lately made at Woolwich would be less effectual than those which have been fired at Meppen with previously unattained velocities, but from lighter, smaller, cheaper, and more manageable weapons. The experiments lately made in Germany will indeed have been thrown away, as far as England is concerned, if they fail to lead to a complete reconsideration of the subject, and to the development of some means for the utilisation, in all that relates to armaments, of the vast mechanical resources of the country.'

The *Times* on Woolwich guns.

Since these criticisms were published great progress has been

made at Woolwich. Already, at the date when the article in the *Times* was published, the War Department was able to dispute the alleged supremacy of Krupp's guns.

Official comparisons—Krupp and Woolwich guns.

The following comparisons were laid before the War Office as the results of experiments made in 1878:—'The Krupp long 30·5 c/m. (German) breech-loader, weighing about 38 tons, firing a battering shell of 725 lbs., with a powder charge of 158·7 lbs., registered a muzzle velocity of 1,645 feet per second, equivalent to a total energy of 13,604 tons. The Woolwich chambered 38-ton muzzle-loading gun (of which there are only two or three in existence), with an 810-lb. shell, and 200 lbs. of powder, registered 1,560 feet velocity, or 13,668 tons. In the comparison of these two guns, the difference in their bores must be considered, the English weapon having a calibre of 12·5 inches, and a length of 198 inches, while the German gun is 12·01 inches only in the bore, which is 264·6 inches long. The lesser weight of the Krupp shot consequently brings it to the front in calculating the energy per inch of shot's circumference, in so far as the inch of circumference formula can be accepted as correct, the record being 360 for the German, and 350 for the English gun. This difference, small in comparison with the disparity of length, has since been reversed, and the energy for each inch of the shot's circumference is now about 5 tons in favour of the British gun. The Elswick (Armstrong 40-ton breech-loader of 12-inch bore) takes the third place; with a length of bore practically the same as that of the Krupp gun (264 inches), it fired a shell of 700 lbs. with a charge of 190 lbs. of powder, and realised a velocity of 1,637 feet, or an energy of 13,007 tons, being 345 tons per inch. The French 38-ton breech-loader, which has a bore of 12·6-inch calibre, and is 243 inches long in the bore, fired only 139 lbs. of powder with its 770-lb. shot, and registered 1,371 feet velocity, which represents 10,036 tons of energy, or 253 tons per inch; while in the corresponding guns of the Italians, by increasing the cartridge to 150 lbs., the velocity was raised to 1,411 feet per second, and the energy to 10,630 tons, or 268 tons to the inch. The Russian great gun corresponds in weight and calibre with that of Sir William Armstrong's, being a 12-inch breech-loader of 40 tons; but it has been tried with a powder charge of 120 lbs. only, and a 650-lb. projectile. The small diameter has given it a velocity of 1,398 feet per second; but the energy works out at only 8,808 tons, or 234 tons per inch.'

Cost of guns.

The distinguishing merit of the Woolwich gun has been its cheapness. The object of Mr. Fraser's inventions, as it has already been stated, was to introduce a less costly method of manufacture.

The success with which this object has been attained is sufficiently shown by the following official figures. The Krupp guns cost five francs per kilogramme, equal to 2·205 lbs. avoirdupois, as against three francs per kilogramme for the Armstrong guns. The Krupp steel gun of 71 tons cost 22,000*l.*; the Armstrong 100-ton coiled wrought-iron gun, 16,000*l.*; the Woolwich (Fraser) wrought-iron coil gun, 80 tons, 10,000*l.*

The prices quoted for Woolwich, as against other guns, merely give the money cost per unit of dead weight. The heavier, and consequently more unwieldy, and less suitable for naval service a gun is, the cheaper it is made to appear on this system. Should not the price be—as is the rule with steam-engines—per unit of power? Say, so much per foot-ton of energy at 1,000 yards; or for each *foot-ton of energy per ton weight of gun.*

Money price per unit of dead weight gives an imperfect idea of the real cost of a gun. Such a quotation of price makes an inefficient heavy gun appear cheaper than a light powerful one. The price of Krupp's guns per unit of dead weight is between two and three times that of the Woolwich gun; but per unit of energy perhaps hardly twice as much; endurance and strength not being considered. The quoted price of Woolwich guns is merely their cost when finished in the factory, and takes no account of the cost of proving, transporting, and of making range-tables, nor of their share of the maintenance of a practice ground. These matters enter into the computation of price by private makers.

Woolwich guns with enlarged chambers.

The rivalry between Woolwich and Essen has been assiduously sustained, and great efforts have been made to produce a higher result from the 80-ton gun than anything which has been hitherto accomplished in Germany. A gun was prepared for the great experiments at Essen, having a diameter of 15·76 inches, which fired a projectile of 1,709 lbs. with a powder charge of 451 lbs., with a muzzle velocity of 1,648 feet per second, which was calculated as equivalent to an energy of 32,322 foot-tons, or a penetration of 32 inches of armour. The War Office authorities, being unable to give their guns the same length which has been given to those manufactured by Herr Krupp (his gun having a bore 343 inches long, whilst ours has only one of 288 inches), determined to enlarge the bore of their gun from 15½ to 16 inches, and to scoop out still further the chamber of the gun. The result was highly successful. A projectile of 1,760 lbs. was fired with 445 lbs. of powder, attaining a muzzle velocity of 1,657 feet per second, which is equivalent to a penetrative power in excess of that attained by Herr Krupp, and

amply sufficient to penetrate any enemy's vessel coated with 32 inches of armour.

Table of Comparison between Heaviest Armstrong, Woolwich, and Krupp Gun.

	Armstrong 100-ton Gun	Woolwich 80-ton Gun	Krupp 71-ton Gun
Material	Steel and Wrought Iron	Steel and Wrought Iron	Steel
Calibre, inches	17·72	16	15·75
Length, total feet	32·65	26·75	32·8
Length of bore, feet	30·25	24	38·6
Place and date of trial	Spezia, June 23, 1879	England, Sept. 1879	Meppen, July 16, 1879
Weight of projectile, lbs.	2,100	1,709	1,715
Ratio of weight between gun and projectile	105·59	104·18	92·55
Weight of charge, lbs.	550	445	485
Initial velocity, feet per second	1,673	1,657	1,703
Total energy at muzzle, foot-tons	40,973	32,366	34,508
Energy per inch of circumference of projectile	734·8	647·15	698
Energy per pound of powder	74·5	72·7	71·2
Energy per ton of gun	409·73	404·5	487
Pressure of gas, tons per square inch	20·38	21·5	20·92
Penetrating power, inches of iron	36	31·98	33·5

At the prices quoted above the cost per ton of dead weight would be for the 80-ton gun about 125*l.*, for the 100-ton gun about 160*l.*, and for the 71-ton gun 310*l.* But per *foot-ton of energy for each ton of gun*—which should be the governing element in a naval gun—the prices would be for the Woolwich gun 24*l.*, for the Armstrong 39*l.*, and for the Krupp 45*l.*, showing a considerable change in the proportions.

The relative merits of the breech-loading and muzzle-loading systems demand attentive consideration in connection with the future armament of Her Majesty's ships. In the case of broadside vessels, the dimensions of the ship must be governed in an important degree by the nature of the ordnance to be carried. In a letter addressed by the late Rear-Admiral Sherard Osborne to the *Times* of May 3, 1875, the gallant writer made the following observation:—'First recognising the Duke of Somerset's successful efforts to substitute "Forward" on the doors of Her Majesty's gun factory at Woolwich for the word "Finality," he proceeds to refer to the "Sultan" of 9,000 tons burden, mounting only 12 guns, of which eight are on the broadside. Her main deck battery,' he says, 'consists of 18 muzzle-loaders each 15 feet long. The naval constructor

Rear-Admiral Sherard Osborne.

had, therefore, in building her, to deal with a beam or width to the ship sufficient to allow two 15-feet guns to come inboard for loading, and leave room for a small passage-way in the rear and the necessary hatchway. These elements, together with the thickness of her side and armour, amount to a big figure, and constitute the beam of an ironclad. The beam, as everyone knows, governs the length of a ship, and the two together may be said to govern tonnage, so that it is the great length of muzzle-loaders which, to no small extent, causes our ironclads to be of such enormous bulk in proportion to their armament.

'Now a breechloader, apart from all its merits, should also be a non-recoil gun; and the shipbuilder, instead of having to deal with its entire length, would only have to consider what portion of the gun need be inboard in action; therefore length inboard would be so much less, beam so much less, and the size of the ship greatly reduced. In fact, I maintain that the armament of the "Sultan" in breech-loading guns could be carried in a ship of much less tonnage and cost than the "Sultan," and that we should in such case very quickly recoup the country the four millions already spent in the muzzle-loading system, and for which some are ready to risk the safety of the State.

'Furthermore, assume that a smaller "Sultan" was carrying 18-ton breech-loaders, instead of muzzle-loaders, and that those guns were 50 per cent. more powerful, as Sir Joseph Whitworth is ready to rest his credit upon, should we not have gained enormously in both cost and power?'

The general current of opinion in foreign services has of late been setting most distinctly in favour of the breech-loading system. In an official report issued in 1876 by the Bureau of Ordnance of the United States Navy, prepared by Commodore William Jeffers for the information of Mr. Robeson, the Secretary to the United States Navy, we have the following expression of opinion:—

Report of Bureau of Ordnance U.S.N., 1876.

'After studying the various systems in use, I am convinced that the breech-loader is best adapted to the conditions of naval warfare. I am mainly governed on this subject by the consideration that great length of bore is necessary for an efficient rifle; but as the beam of the ship is limited, and the heaviest guns may be carried on quite small vessels when mounted on carriages, on the non-recoil system, breech-loading is essential.'

The muzzle-loading Armstrong guns were highly esteemed in Austria, especially on the ground of cheapness. The superior endurance of the Krupp guns made of cast-steel, and the superior

accuracy of fire attained with the breech-loader, have gradually led to the adoption of the Krupp system for all armour-piercing guns in the Austrian navy.

'Rivista Marittima,' 1879. In an article which appeared in 1877 in the *Rivista Marittima*, the relative merits of the breech-loading and the muzzle-loading systems were carefully summed up. For the breech-loading system the following advantages were claimed:—

(1) Less space for the recoil.
(2) Greater facility in loading.
(3) A grommet wad is unnecessary.
(4) Greater facility for unloading and examining the interior of the piece.
(5) The gun's crew are less exposed to musketry fire while loading.

The objections to breech-loading are:—

(1) Greater complication of manufacture.
(2) The management of the gun requires greater care.
(3) Greater risk of the gun getting out of order.
(4) Risk of escape of gas at the breech.
(5) Risk that the breech has not been properly closed.
(6) Greater difficulty of securing such strength at the breech as to prevent the gun from losing something of its energy and power after a long-continued use.

Lieutenant Falsen, Norwegian navy. Another authority, Lieutenant Falsen, of the Norwegian Navy, gives the following enumeration of the advantages which may be claimed for the breech-loader:—

(I.) Firing.

(*a*) Better combustion in the powder-chamber.
(*b*) The guns can be of greater length, which admits of a heavier charge of powder, and greater initial velocity.
(*c*) The projectile is better directed by the grooves, and better centred.

(II.) Service of the Gun.

(*a*) The gun's crew are better protected.
(*b*) Heavy projectiles are more easily loaded.
(*c*) It is easier to draw the charge;
(*d*) and to clean the gun.
(*e*) There is less danger of premature explosion.

An authoritative declaration of the opinion of those in charge of the Royal Gun Factories has recently been made in the Report issued by General Younghusband to the War Office, after the return of that officer from attendance at the experiments at Bredelar and Essen in 1878. The writer points to the fact that the introduction of a slow-burning powder has given increased value to length of bore. We have already seen, in the extract from Rear-Admiral Sherard Osborn's letter, how great length of gun must be attended with extreme inconvenience on board the ship in the case of muzzle-loaders. Again, the enlarged powder chamber can be introduced more readily in breech-loading than in muzzle-loading guns. The writer in a German professional paper remarks:—'Hydraulic or other mechanical means being necessary to load the monster guns of 81 tons, the breech-loading system cannot compete with the muzzle-loading, unless means can be devised for transporting shot within the axis of the turret as rapidly as it can be done outside the turret.' In an open barbette battery, where steam power can be applied for all the operations of loading and traversing, preference is again given to the muzzle-loader. But if steam or other stored-up power is not available, or if it is thought inadvisable to trust to such alone, then the balance of advantage is considered to be on the side of the breech-loader. An important feature in the breech-loading gun is the ease with which it can be worked by hand. The official report speaks of this when referring to the Krupp guns of 38 tons and 51 tons. The foregoing considerations seem to point generally to the introduction of breech-loading guns in large proportions into the armament of our ships of war.

Projectiles.

In concluding these remarks upon armament, attention may be directed to a paper by Admiral Scott, on the 'Maritime Defence of England,' read before the Royal United Service Institution on June 16, 1876. The writer makes some observations with reference to projectiles and gun-carriages, which deserve consideration on the part of our naval administration:—'We adhere to cast iron for our projectiles; we found chilled shot the best thing known at one time, and we adhere to them, regardless of the superiority of steel.' 'Steel projectiles must be used to attack steel-faced armour; chilled are but little use against it.'

It clearly appears from this brief survey, that the latest improvements in gunnery are almost entirely due to the inventive genius and enterprise of private individuals—to Vavasseur, Armstrong, Whitworth, Palliser, and Krupp. If reductions of cost have been effected at Woolwich, there is reason to believe that by com-

petition the cost of guns would have been reduced in at least equal proportions, if we had relied entirely on the private manufacturers. We have resources here outside the public establishments which are not found in any other country. Every facility which has been created at the public expense would have been found in the private factories and foundries, if they had been encouraged sufficiently by the patronage of the State. It is now too late to reverse our policy. The Government has wisely determined to seek the advice of the ablest officers, naval and military, and to produce guns which shall be second to none in power and efficiency. For cheapness of manufacture Woolwich will doubtless retain its well-earned reputation. We have hesitated too long in the adoption of the breech-loader; but now, having accepted that system, we may be confident that we shall rapidly come to the front.

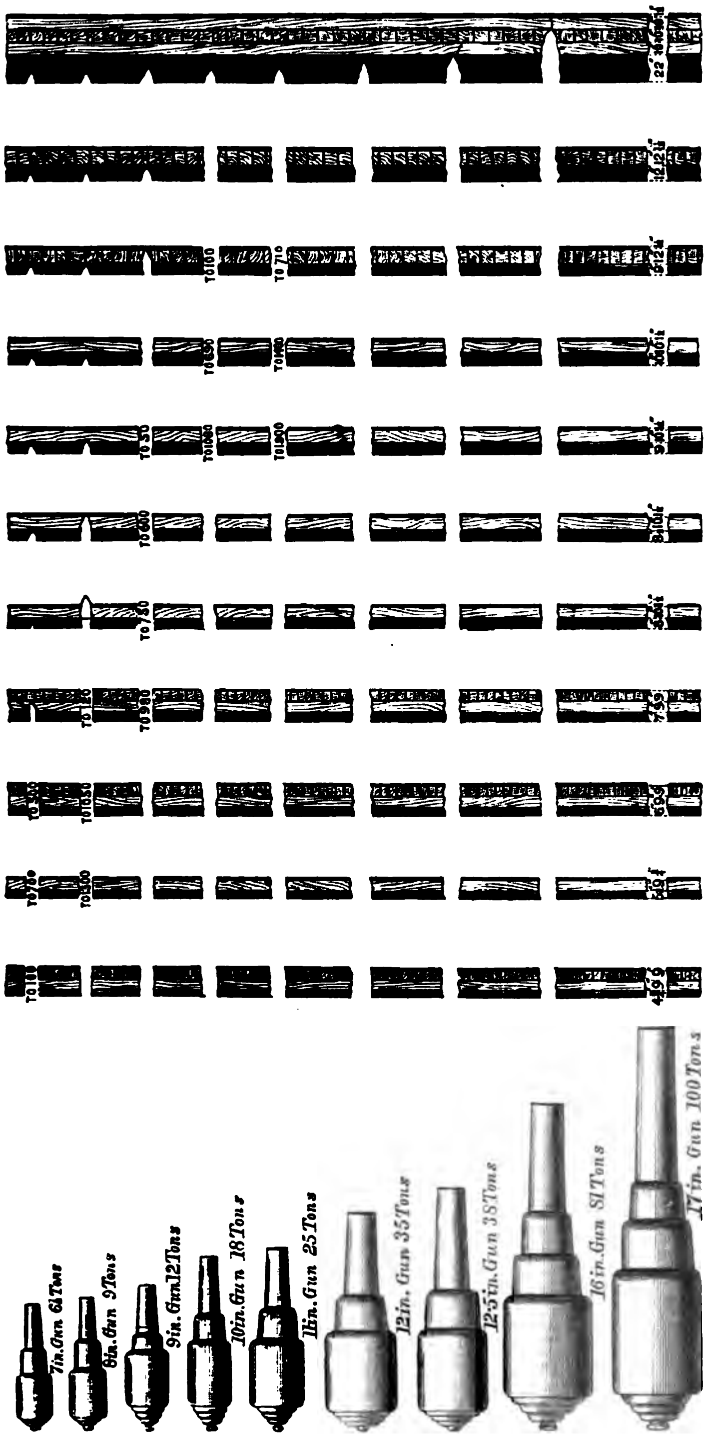
The same arguments may be urged against monster guns as against monster ships. In guns, as in steam rams, the advantages of numerical superiority must always be most important. The last Annual Report of Mr. Thompson, the Secretary of the United States Navy, contains the following observations, which will commend themselves to every naval administrator. After stating that the guns of the 'Inflexible' cost 14,400*l.* each, he points out that in all the European experiments, both guns and targets have been stationary. The process of firing by one ship at another ship, when both are in motion, is a different thing. The same accuracy of flight cannot be obtained; and it is yet doubtful whether these large expenditures are justifiable, when it is considered that where one projectile will strike the narrow surface exposed upon a monitor, a large number will fail to do so.'

At the present time, 43-ton breech-loading guns are in course of manufacture at Woolwich, and if the system adopted be found to answer on trial, it will be extended to guns of all natures which are in use in the navy.

The present arrangements for the supply of gun-carriages to the navy are not quite satisfactory. The demands of the naval authorities upon the War Department involve much interchange of correspondence and loss of time. It is worthy of consideration whether the gun-carriages and mounting-gear might not be supplied more conveniently and promptly, and perhaps more economically, if the navy were to undertake this description of work for themselves.

It seems desirable that the navy should avail itself from time to time of the resources at the disposal of private manufacturers for the manufacture of naval guns.

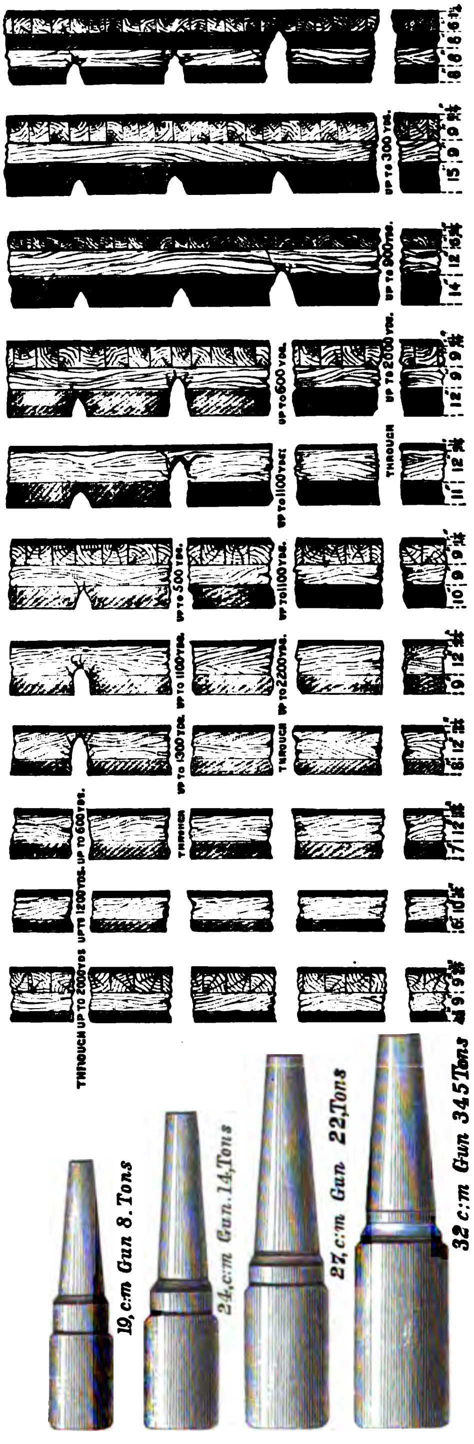
Fig. 81.



PENETRATING POWER OF BRITISH M.L. GUNS.

NOTE.—The figs. marked " show the thickness of armour and backing. The figs. 100, 700, 1,300 &c. give the distance in yards.

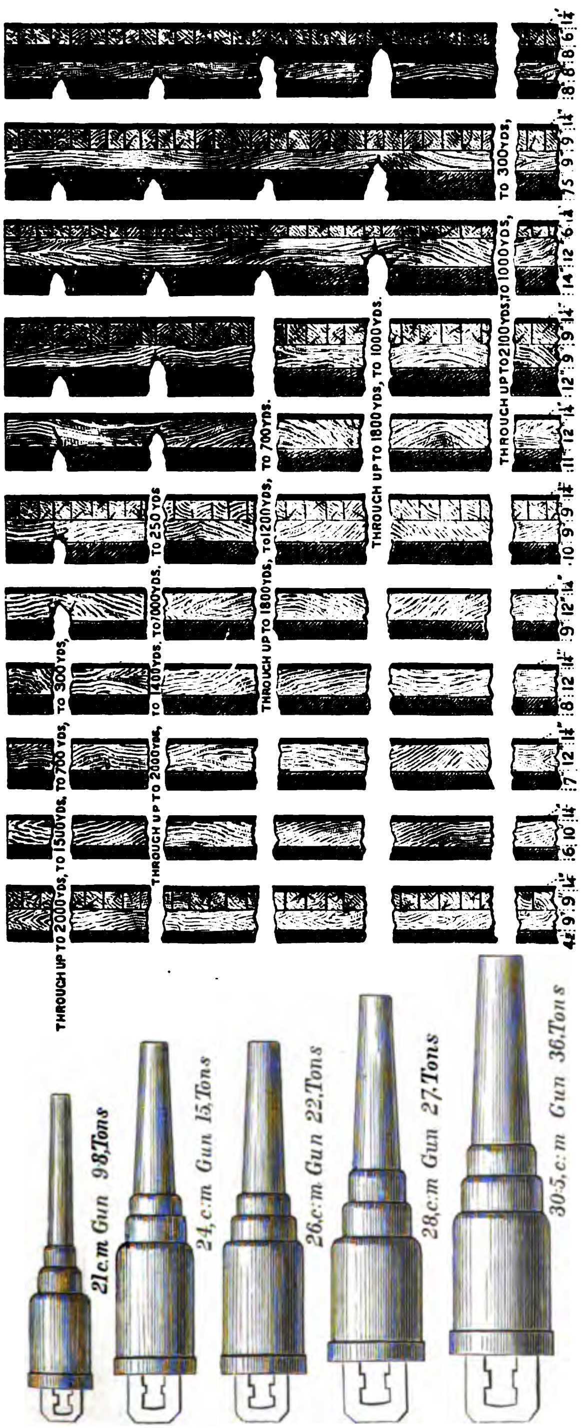
Fig. 82.



PENETRATING POWER OF FRENCH B.L. GUNS.

See note, p. 101.

Fig. 83.



PENETRATING POWER OF GERMAN B.L. GUNS.

See note, p. 101.

TABLES OF ORDNANCE OF

ENGLISH

Classification	Name, Nature, and Classification	Length: Over all	Length: Rifled Bore	Length: Powder Chamber	Number of Grooves	Twist of Rifling	Projectiles: Entire Weight: Chilled	Projectiles: Entire Weight: Common	Projectiles: Entire Weight: Shrapnel	Projectiles: Weight: Burster for Chilled	Projectiles: Weight: Burster for Common
		in.	in.	in.		calib.	lbs.	lbs.	lbs.	lbs.	lbs.
Muzzle-loading, built-up Guns. Woolwich pattern. Armour-piercing	16-inch, 80-ton .	301	231·5	56·5	33	$\frac{0}{50}$	1,700	Not	yet	fixed.	—
	12·5 „ 38 „ .	230	170·5	27·5	9	$\frac{0}{35}$	802	809	—	12	29·25
	12 „ 35 „ .	195	135	27·5	9	$\frac{0}{35}$	700	615	612	9·9	40
	12 „ 25 „ .	182·5	127	18	9	$\frac{100}{50}$	600	497	497	14	37·7
	11 „ 25 „ .	180	119	26	9	$\frac{0}{35}$	535	536	—	6·5	29·7
	10 „ 18 „ .	180	119	26·5	7	$\frac{100}{40}$	400	398	404	6·8	20·25
	9 „ 12 „ .	156	104	21	6	$\frac{0}{45}$	250	250	255	5·5	19
	8 „ 9 „ .	144	99·5	18·5	4	$\frac{0}{40}$	180	182	180	4·5	14·5
	7 „ 90-cwt. .	133	95·5	15·5	3	35	115	117	116	2·5	8·75
Muzzle-loading, built-up Guns. Woolwich pattern	7 „ 6½-ton .	133	95·5	15·5	3	35	115	117	116	2·5	8·75
	64-pdr., 64-cwt., shell	118	90	7·5	3	40	—	64	66	—	7·2
Muzzle-loading. Boat	9 „ 8 „	72	59·8	3·7	3	30	—	9	9·75	—	·5
	9 „ 6 „	61	49·3	3·7	3	30	—	9	9·75	—	·5
	7 „ 200-lb., steel	41	34	2	3	20	—	7	7·5	—	·4
	64 „ 71-cwt., converted	122·7	96·27	7	3	40	—	64	66 Segment shell.	—	7·2
Breech-loaders. Early Armstrong pattern. Shell	7-inch, 82 cwt.	120	83·5	16	76	37	—	90	102	—	7·6
	40-pdr., 32 „	120	92·87	13·5	56	36·5	—	38	40	—	2·25
	40 „ 35 „	121	92·87	13·5	56	36·5	—	38	40	—	2·25
	20 „ 15 „	66	43·12	11	44	38	—	20·5	20	—	1·2
	20 „ 13 „	66	43·12	11	44	38	—	20·5	20	—	1·2
Breech-loaders. Boat	9 „ 6 „	62	45·5	7	38	38	—	9·5	8·5	—	·4
	6 „ 3 „	60	46	7	32	30	—	6	5·5	—	—
	12 „ 8 „	72	52·87	8·5	38	38	—	11·25	11	—	·5

'HE PRINCIPAL NAVAL POWERS.

RDNANCE.

Powder Charge				Muzzle Velocity per Second		Muzzle Energy		Penetration (Iron)		Remarks
For Steel and Chilled Shot	For Common Shell	Ordinary Firing	Saluting	Chilled Shot	Common Shell	Chilled Shot	Common Shell	At 500 Yards	At 1,000 Yards	
lbs.	lbs.	lbs.	lbs.	feet	feet	foot tons	foot tons	in.	in.	
450	—	—	—	?1,657	—	?32,366	—	—	—	
130 P²	100 P²	—	—	1,415	—	9,645	—	16·2	18·0	
110 P	85 P	85	—	1,300	—	8,367	—	15·4	14·9	
85	67	55	—	1,300	—	7,195	—	13 9	13·35	Woolwich groove. Increasing twist.
85	70	60	—	1,315	—	6,559	—	13·8	13·4	
70	60	44	—	1,364	—	5,288	—	12·7	12·2	
50	43	30	15	1,420	—	3,607	—	10·4	10·2	
35	30	20	12	1,413	—	2,492	—	9·8	8·3	
30	22	14	10	1,361	—	1,477	—	—	—	Woolwich groove. Uniform twist.
30	22	14	10	1,525	1,250	1,854	1,246	7·7	7·1	
—	10	10	6	—	1,383	—	897	—	—	Shunt groove. Uniform twist.
—	1·75	1·75	1·5	—	1,380	—	118	—	—	Modern French groove. Uniform twist.
—	1·5	1·5	1	—	1,390	—	119	—	—	
—	·75	·75	·25	—	968	—	45·5	—	—	French groove. Uniform twist.
—	8	8	6	—	1,230	—	677	—	—	French groove. Uniform twist.
—	11	11	7	—	1,165	—	847	—	—	
—	5	5	3	—	1,180	—	386	—	—	
—	5	5	3	—	1,180	—	386	—	—	
—	2·5	2·5	1·5	—	1,000	—	142	—	—	Armstrong multigroove. Uniform twist.
—	2·5	2·5	1·5	—	1,000	—	142	—	—	
—	1·1	1·1	1	—	1,035	—	64	—	—	
—	·75	·75	·7	—	1,046	—	45·6	—	—	
—	1·5	1·5	1	—	1,239	—	117	—	—	

FRENCH

		Name, Nature, and Classification	Calibre	Length: Over all	Length: Bore	Number of Grooves	Twist of Rifling	Projectiles: Complete Weight: Steel	Complete Weight: Chilled	Complete Weight: Common	Complete Weight: Canister	Weight: Bursting Charge Common Shell
			in.	in.	in.	in.	in.	lbs.	lbs.	lbs.	lbs.	lbs.
French pattern, cast-iron, steel-lined Breech-loaders	Pattern of 1870	32 c/m. . 38½ tons	12·6	264·4	224	32	$\frac{0}{45}$	770	770	630	—	37·4
		27 „ . 23 „	10·8	212	194	28	$\frac{0}{45}$	475	475	396	317	24
		24 „ . 15½ „	9·46	195	179	24	$\frac{0}{45}$	317	317	264	220	17
		19 „ . 7¾ „	7·64	164	151	20	$\frac{0}{45}$	165	165	137·5	114	7
		16 „ . 5 „	6·49	146	135	16	$\frac{0}{30}$	99	99	84	69	—
		14 „ . 53 cwt.	5·46	123	115	14	$\frac{0}{30}$	—	—	46	41	2·4
	Pattern of 1864–67	27 „ . 20 tons	10·8	184	167	5	$\frac{0}{30}$	—	475	317	321	14·6
		24 „ . 14 „	9·46	180	165	5	$\frac{0}{30}$	—	317	220	211 220	10·3
		19 „ . 7¾ „	7·64	150	138	5	$\frac{0}{30}$	—	165	115	105	4·8
		16 „ . 4¾ „	6·49	133	124	3	$\frac{0}{30}$	—	99	69	66	3
		14 „ . 36 cwt.	5·46	81	73·6	3	$\frac{0}{30}$	—	—	41	27 39·6	2·1
Bronze Muzzle-loaders		12 „ . 12 „	4·78	81·4	71·5	6	—	—	—	25	24·6	1·1
		4 „ . 2 „	3·41	37·8	31·7	6	—	—	—	10	10	·17
		Hotchkiss Machine gun . . .	1·46	51·2	29·1	—	—	—	—	1	—	—
Pattern of 1858–60 Muzzle-loaders		22 c/m. . . .	—	—	—	—	—	—	—	—	—	—
		16 „ . . .	—	—	—	—	—	—	—	—	—	—
		14 „ . . .	—	—	—	—	—	—	—	—	—	—
		New guns, (steel tubed and hooped)										
	Pattern of 1875	34 c/m. . 46 tons	13·38	264	241	68	—	927	—	782	—	42·6
		27 „ . 27 „	10·8	231	213	54	—	476	—	397	—	24·1
		27 „ . 24 „	10·8	231	213	42	—	476	—	397	—	24·1
		10 „ . 24 cwt.	3·94	111	90	20	—	—	—	25·4	—	1·3

NAVAL ORDNANCE.

Powder Charge				Initial Velocity per Second			Muzzle Energy			Penetration	
Steel and Chilled Shot	Common Shell	Ordinary	Saluting	Steel	Chilled	Common	Steel	Chilled	Common	Steel	Chilled
lbs.	lbs.	lbs.	lbs.	lbs.	feet	feet	foot tons	foot tons	foot tons	in.	in.
132	132	—	—	1,394	1,394	1,496	10,390	10,390	9,730	14·5	14·5
92·4	92 4	52·8	19·8	1,417	1,417	1,542	6,596	6,596	6,506	12·5	12·5
61·6	61·6	35·2	13·2	1,443	1,443	1,555	4,561	4,561	4,414	11·1	11·1
33	33	17·6	7·7	1,456	1,456	1,726	2,330	2,330	1,828	9	9
20·9	20·9	—	—	1,575	1,575	1,660	1,698	1,698	1,598	8·2	8·2
—	9	9	3·3	—	—	1,493	—	—	712	—	—
79·2	52·8	52·8	19·8	—	1,086	1,188	—	3,871	3,088	—	9·6
52·8	35·2	35·2	13·2	—	1,115	1,188	—	2,821	2,144	—	8·75
27·5	17·6	17·6	7·7	—	1,128	1,168	—	1,451	1,081	—	7·0
16·5	11	11	5·5	—	1,132	1,197	—	876	687	—	5·87
—	4·4	4·4	4·4	—	—	1,053	—	—	314	—	—
—	2·2	2·2	2·2	—	—	1,007	—	—	176	—	—
—	·66	·66	·66	—	—	738	—	—	39	—	—
—	·18	—	—	—	—	1,318	—	—	—	—	·94
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
278	—	—	—	1,640	—	—	14,676	—	—	—	—
136	121	—	—	1,640	1,656	—	7,201	—	—	—	15
104	—	—	—	1,542	(?)1,656	—	6,350	—	—	—	14
6·8	—	—	—	—	1,591	—	—	—	—	—	—

GERMAN

	Name, Nature, and Classification	Calibre	Length			Number of Grooves	Twist of Rifling	Full
			Over all	Rifled Bore	Powder Chamber			Chilled
		in.	in.	in.	in.		calib.	lbs.
Krupp's pattern steel Breech-loaders	30½ c/m. hooped . . 36 tons	12	264	172	54·7	72	45	715
	28 „ „ and tubed 28 „	11·15	240	171	46·1	36	70	561
	28 „ „ . . 28 „	10·34	240	171	46·1	36	70	561
	26 „ long hooped . 22½ „	10·24	225	138·5	55·3	36	50	411
	26 „ short „ . . 18½ „	10·24	205	128	42·1.	36	50	411
	24 „ long „ . . 15¼ „	9·27	206	136	38·4	32	70	308
	24 „ short „ . . 14½ „	9·27	185	115·4	38·4	32	65	308
	21 „ long „ . . 10 „	8·24	185	124·6	33·7	30	68	216
	21 „ short „ . . 9¼ „	8·24	154	96·8	31·4	30	59	216
	17 „ long „ . . 5 „	6·8	167	107·5	40·8	30	45	123
	17 „ short „ . . 5¾ „	6 8	134	92	24·7	30	59	121
	17 „ short, light hooped, 72 cwt.	6·8	136	92·7	25·7	30	45	117
	15 „ long hooped . 80 „	5·87	152	105·8	27	24	45	78
	15 „ short „ . . 72 „	5·87	129	86·8	23·5	24	68	78
	15 „ tubed „ . . 66 „	5·87	128	86·8	23·5	24	65	78
	12 „ hooped „ . . 29 „	4·74	115	85·7	14·7	18	60	38
	8 „ heavy „ . . 7 „	3·19	76	57·6	8·4	12	46	—
	8 „ light „ . . 6 „	3·19	76	57·6	8·4	12	46	—
	8 „ . . . . 4½ „	2·20	62	45·9	7·7	12	46	—
	4 „ . . . . 160 lbs.	1·54	69	54·7	9	12	70	—

'AL ORDNANCE.

Projectiles			Powder Charge			Penetrating Power	Initial Velocity per Second		Working Effect	
t	Bursting Charge									
	Chilled	Common	For Steel and Chilled Shot	For Common Shell	Saluting		Chilled	Common	Chilled	Common
	lbs.	lbs.	lbs.	lbs.	lbs.	in.	feet	feet	foot tons	foot tons
·5	8	22	158·4	158 4	—	16·4	1,591	1,623	12,584	11,176
7	7·7	25 3	132	132	—	14·4	1,515	1,640	8,960	8,931
7	7·7	25 3	132	132	—	13·3	1,515	1,610	7,210	8,931
7	5 28	17·27	107·8	107·8	17·6	13	1,587	1,640	6.802	6,876
7	5·28	17·27	107·8	107·8	17·6	11·5	1,430	1,387	4,835	6,466
1	3·19	15·4	59·4	44	17·6	11·27	1,502	1 391	4,(25	3,511
1	3·19	15·4	59·4	44	17·6	10 05	1,469	1,355	4,625	3,327
5	2·75	10·45	41·8	30·8	13·2	8·9	1,476	1,394	3,275	2,348
5	2·75	10·45	35·2	26·4	13·2	8·55	1,312	1,394	2,587	1,970
2	1·21	9·24	26·4	22	6·6	7·25	1,548	1,525	1,944	1,809
9	1·21	6·6	17·6	14·3	6 6	7·33	1,279	1,279	1,399	1,127
2	1·32	5·94	16·5	16·5	6·6	7·88	1,325	1,341	1,437	1,411
3	7·7	6·5	18·7	15·4	4·4	6·7	1,623	1,615	1,431	1,172
1	7·7	4·4	13·2	12·1	4·4	6 58	1,477	1,591	1,030	1,072
1	7·7	4·4	13·2	12·1	4·4	5·6	1,358	1,446	1,001	888
3	—	2·48	7·7	4·62	2·31	5·6	1,476	1,230	584	345
·5	—	·6	—	1·1	1·1	—	—	1·118	—	84
5	—	·6	—	1·1	1·1	—	—	1,118	—	84
·7	—	·6	—	·98	1·1	—	—	1,135	—	66·5
	—	·28	—	·41	—	—	—	1,837	—	—

ITALIA

Classification	Name, Nature, and Classification	Calibre	Length: Over all	Length: Rifled Bore	Length: Powder Chamber	Number of Grooves	Twist of Rifling
		in.	in.	in.	in.		cal[illegible]
Armstrong pattern Muzzle-loaders	45 c/m. . . . . 100 tons	17	392	311·3	52	27	[illegible]
	28 „ New Pattern . 25 „	11	173	120·5	24 4	9	[illegible]
	28 „ Old „ . 25 „	11	173	119	26	8	[illegible]
	25 „ No. 1 Long . 17¾ „	10·1	173·2	119·1	26	7	[illegible]
	25 „ „ Short . 18 „	10·1	167·6	113·9	26	7	[illegible]
	25 „ No. 2 . . 12 „	10·1	156·1	111·1	14	8	55
	22 „ . . . . 12¾ „	9	156·1	105·6	19·7	6	[illegible]
	20 „ . . . . 7 „	8	130	88 6	15·8	6	45
Cast-iron Muzzle-loaders	16 „ Wrought-iron Tube 5 „	6·5	142·1	104	13 8	6	42[illegible]
	16 „ . . . . 71 cwt.	6·5	126·7	94·1	13·9	6	42[illegible]
Armstrong Breech-loader	12 „ . . . . 23¾ „	4·7	—	70·4	19·7	27	—
Bronze Breech-loader	7·5 „ . . . . 5½ „	2·95	70·1	52·4	10·2	12	48[illegible]
Bronze Muzzle-loaders	8 „ . . . . 6¾ „	3·4	—	45·3	9·8	6	25
	8 „ . . . . 2 „	3·4	—	31·9	3·5	6	25
Cast-iron Muzzle-loader	12 „ . . . . 13 „	4·77	—	73·3	6·3	6	2[illegible]

The 100-ton B.L. gun made by Armstrong and Co. is about to be mounted in the latest Ital[illegible]
Armstr[illegible]

NAVAL ORDNANCE.

Projectiles					Powder Charge				Initial Velocity per Second		Working Effect		Penetration
Weight complete			Bursting Charge										
Steel	Chilled	Common	Chilled	Common	Chilled	Common	Ordinary	Saluting	Chilled	Common	Chilled	Common	Penetration
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	feet	feet	foot tons	foot tons	in.
2,000	—	—	37	—	471	—	—	—	1,584	—	40,973	—	36·
528	528	200	5·7	26	95	95	66	—	1,312	1,312	6,300	6,300	12·1
528	530	200	5·7	26	95	95	66	—	1,312	1,312	6,262	6,330	12·1
294	300	188	5	24	77	77	53	—	1,410	1,399	5,369	5,890	11·7
294	300	188	5	24	77	77	53	—	1,410	1,399	5,369	5,390	11·7
288	284	135	3·3	18	64	64	42	—	1,410	1,420	3,952	3,970	10
248	252	99	2·2	19	60	60	37	—	1,476	1,476	3,731	3,790	10·3
156	150	79	1·3	9·7	44	44	21	—	1,476	1,509	2,345	2,345	8·7
—	65	33	—	3·3	20	20	7	8	—	1.525	—	1,066	—
—	66	33	—	3·3	—	7·7	—	8	—	1,026	—	483	—
—	35	—	—	2·6	—	5·5	—	2·2	—	1,368	—	457	—
—	8	9	—	·5	—	1·5	—	1·4	—	1,312	—	97·5	—
—	9	9·25	—	·7	—	1·2	—	1·2	—	1,040	—	63·4	—
—	9	4·4	—	·7	—	·7	—	1	—	764	—	33·8	—
—	26	22·6	—	3·1	—	3·3	—	2·2	—	1,095	—	12	—

armour-clads. Some unarmoured Italian vessels carry 6-inch and 40-pdr. B.L. guns of the later pattern.

AUSTRIAN

Name, Nature, and Classification		Calibre	Length: Over all	Length: Rifled Bore	Length: Powder Chamber	Number of Grooves	Twist of Rifling	Preponderance	Projectiles, Full Weight: Steel	Projectiles, Full Weight: Chilled	Projectiles, Full Weight: Common
		in.	in.	in.	in.		calib.	lbs.	lbs.	lbs.	lbs.
Krupp Pattern Steel Breech-loaders	28 c/m., 27 tons . . .	11	240	170·7	36·41	64	45	—	559	574	473
	26 „ 22½ „	10·24	225	148·4	46·06	32	70	—	395	—	354
	24 „ 15¼ „	9·27	206	136	41·7	32	70	—	292	—	263
	24 „ 15 „	9·27	185	115·3	41·7	32	64·7	—	292	308	263
	21 „ 9 „	8 24	165	105	37	30	59	—	206	196	172
Wahrendorff Breech-loader	15 „ 58 cwt. . .	5·87	152	112·4	22·6	36	45	248	84·7	—	69
Armstrong Muzzle-loaders	23 „ 12 tons . .	9	156	104	20·9	6	45	255	—	249	257
	18 „ 6½ „ . .	7	130	85·5	18·7	3	35	394	—	114	118
Cast-iron Breech-loaders	15 „ 56 cwt. . .	5·87	121	89·8	16·9	30	63	299	—	—	61
	12 „ 29 „ . .	4·74	109	84·4	12·4	24	52	273	—	—	32
Bronze Breech-loaders	9 „ 10 „ . .	3·43	81	57·5	16·5	24	45	103	—	—	14
	7 „ 200 lbs. . .	2·6	39	23·8	11	18	30	48·4	—	—	6·4

VAL ORDNANCE.

Projectiles			Powder Charge				Initial Velocity per Second			Working Effect			Penetrating Power
Bursting Charge													
Steel	Chilled	Common	For Steel and Chilled Shot	For Common Shell	Ordinary	Saluting	Steel	Chilled	Common	Steel	Chilled	Common	
bs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	feet	feet	feet	foot tons	foot tons	foot tons	in.
4 3	7·7	25·3	121	121	—	- -	—	1,542	1,673	—	9,473	—	14·8
5·8	—	20·2	70 4	59·4	59·4	19·8	1,404	—	1,378	5,404	—	4,666	11·6
6·6	3·7	14·9	52·8	44	44	15·4	1,420	—	1,378	4,087	—	3,464	10·6
5·6	3·7	14·9	52·8	44	44	15·4	1,378	1,345	1,329	3,838	3,223	3,867	10·25
4·4	3·1	14·9	37 4	30·8	30·8	8·8	1,394	1,253	1,345	2,781	2,198	2,153	9·3
2·1	—	5·1	17 6	14·3	14·3	4·7	1,608	—	1,509	1,379	—	1,060	7·8
—	5·9	18·5	50·6	30·8	30 8	15·4	—	1,411	1,060	—	3,429	1,788	9·9
—	1·1	7 9	28·6	13·2	13·2	8·8	—	1,493	1,066	—	1,766	928	8·1
—	—	1·9	—	4·7	4·7	4·7	—	—	1,017	—	—	438	—
—	—	1·1	—	2·4	2·4	2·4	—	—	1,000	—	—	222	—
—	—	·4	—	·9	·9	·9	—	—	1,469	—	—	209	—
—	—	·16	—	·35	·35	·35	—	—	977	—	—	42	—

RUSSIA[N]

Name, Nature, and Classification				Calibre	Length over all	Number of Grooves	Twist of Rifling	Projectiles: Complete Weight: Steel	Chilled	Common
				in.	in.		calib.	lbs.	lbs.	lbs.
Krupp Russian pattern steel Breech-loaders	Finished	12 inch .	40 tons	12	240·8	36	—	649	—	644
		11 „ .	28 „	11	219	36	70	495	462	439
		9 „ .	15 „	9	180	32	60	270	264	267
		9 „ .	12 „	9	156	32	60	270	264	267
		8 „ .	9 „	8	175	30	60	180	191	182
	Unfinished	6 „ .	4½ „	6	140	24	45	96	85·4	84
		8 „ .	8 „	8	175	30	60	180	191	182
		6 „ .	4¾ „	6	146	24	45	96	85·4	84
		9 pdr. .	16 cwt.	4·2	—	16	—	—	—	24
		4 „ .	7½ „	3·4	70	12	40	—	—	14
Bronze Rifled Muzzle-loaders		8 „ .	15¾ „	4	—	—	—	—	—	26
		4 „ .	7¾ „	3·4	—	—	—	—	—	1[illegible]·5
		4 „ .	8 „	3·4	—	—	—	Cast-iron	Round Shot	13·5
American pattern cast-iron Smooth-bore Muzzle-loaders		20 inch .	48 tons	20	—	—	—	1,000	1,000	–
		15 „ new .	31 „	15	180	—	—	440	440	373
		15 „ old .	19 „	15	170	—	—	440	440	373
		10¾ „ .	11½ „	10·75	168	—	—	160	160	—
		60 pdr. No. 1	5 „	7·6	135	—	—	57·7	57·7	43
		60 „ „ 2	62 cwt.	7·6	—	—	—	57·7	57·7	43
		36 „ „ 1	62 „	6·8	—	—	—	40	40	29
		36 „ „ 2	55 „	6·8	—	—	—	40	40	29
		36 „ „ 3	44 „	6·8	—	—	—	40	40	29
		36 „ „ 4	40 „	6·8	—	—	—	40	40	29
		30 „ „ 1	66 „	6·4	—	—	—	32	32	26
		30 „ „ 2	50 „	6·4	—	—	—	32	32	26
		30 „ „ 3	42 „	6·4	—	—	—	32	32	26
		30 „ „ 4	16½ „	6·4	—	—	—	32	32	26

NAVAL ORDNANCE.

Projectiles: Bursting Charge			Powder Charge				Initial Velocity per Second	Working Effect	Penetration
Steel	Chilled	Common	For Steel and Chilled Shot	Common Shells	Ordinary	Saluting	Steel		
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	feet	foot tons	in.
—	—	16	121	—	58·5	—	1,446	9,408	14·1
12	7	13·5	82·5	—	41·2	9	1,205	5,844	11·6
7	4·5	9·5	47	—	23·4	7·2	1,341	3,365	9·8
7	4·5	9·5	43	—	23·4	7·2	1,276	3,043	9·3
5	2	6·2	28·5	—	14·2	7·2	1,404	2,463	9·9
—	1·8	3	18	—	10 8	4·5	1,335	1,188	7·1
5	2	6	22·5	—	14·2	7·2	1,246	1,938	7·8
—	1·8	3	14·4	—	10 8	4·5	1,207	972	6·4
—	—	1	—	2·7	2·5	2·7	Common 1,049	183	—
—	—	·5	—	1·5	1·5	1·5	Common 1,003	96	—
—	—	1·5	—	3·6	3·6	3·6	—	—	—
—	—	·8	—	1·5	1·5	1·5	Common 1,000	77	—
—	—	1	Cast-iron Round Shot	2	1·8	1·8	—	—	—
—	—	—	117	—	—	—	1,118	8,581	—
—	—	10·75	67·5	45	27	9	1,184	4,263	—
—	—	10·75	67·5	45	27	9	971	2,872	—
—	—	—	36	—	—	9	—	—	—
—	—	1·8	14·5	—	10	4·5	—	—	—
—	—	1·8	10·8	—	2·6	4·5	—	—	—
—	—	1	8	—	2	3·6	—	—	—
—	—	1	8	—	2	3·6	—	—	—
—	—	1	6·2	—	1·6	3·6	—	—	—
—	—	1	5·5	—	1·4	3·6	—	—	—
—	—	·8	9	—	2·3	2·7	—	—	—
—	—	·8	6·7	—	1·7	2·7	—	—	—
—	—	·8	5	—	1·2	2·7	—	—	—
—	—	·8	3·5	—	·9	2·7	—	—	—

UNITED STATES

	Name, Nature, and Classification		Gun			
			Length of Bore	Calibre	Number of Grooves	Twist of Rifling
			inches	inches		feet
Muzzle-loading Rifles	8-inch converted	7½ tons	136	8	15	40
	100-pdr. Parrott	86 cwt.	130	6·4	9	$\frac{0}{18}$
	60-pdr. „	48 „	105	5·3	7	$\frac{0}{15}$
	30-pdr. „	31 „	—	4·2	5	$\frac{0}{12}$
	20-pdr. „	16 „	—	3·7	5	$\frac{0}{10}$
	20-pdr. Dahlgren	12 „	65·6	4	3	12½
	12-pdr. bronze	8 „	55	3·4	3	10
Breech-loading Rifles	80-pdr. converted	4½ tons	—	6·4	9	$\frac{0}{18}$
	60-pdr. „	47 cwt.	—	5·3	7	$\frac{0}{15}$
	30-pdr. „	30 „	—	4·2	5	$\frac{0}{12}$
	20-pdr. bronze, converted,	12 „	—	4	6	12½
	20-pdr. converted	16 „	—	3·7	5	$\frac{0}{10}$
	7-pdr. bronze, heavy	4½ „	—	3	16	7½
	7-pdr. „ light	3½ „	—	3	16	7½
					Weight of Shot lbs.	
Smooth-bores	15-inch	19 tons	146	15	450	
	11-inch	7 „	131	11	166	
	9-inch	80 cwt.	107	9	90	
	8-inch	58 „	96	8	65	
	32-pdr.	40 „	92	6·4	32·5	
	24-pdr. bronze	12 „	58	5·8	Shell Guns	
	12-pdr. „ heavy	7 „	55	4·6	Shell Guns	
	12-pdr. „ light	4 „	50	4·6	Shell Guns	

The Report of the Secretary of the Navy for 1880 contains an account of experiments with a 10-inch breech-closing arrangement. It fired a 250-lbs. projectile with 45 lbs. of 'hexagonal' powder. The

AVAL ORDNANCE.

Weight of Shell	Charge of Powder in Shell		Powder Charge	Initial Velocity per Second	Muzzle Energy
lbs.	lbs.	oz.	lbs.	feet	foot tons
180	10	0	35	1,450	2,627
100	3	11	15	1,080	810
48	2	2	6	1,320	—
29	1	8	3¼	—	—
18	0	13	2	—	—
18	1	0	2	—	—
12	0	8	1	—	—
80	3	11	15	1,250	—
50	—		6	—	—
30	—		3½	—	—
18	0	8	2	—	—
20	—		2	1,070	—
7	—		1	1,087	63
7	—		¾	1,087	63
352	13	0	100	1,600	7,997
136	6	0	30	1,062	1,300
74	3	0	13	1,320	847
53	1	11	7	—	—
27	0	14	6	—	—
23	1	0	2	—	—
12	1	0	1	—	—
12	1	0	½	—	—

Parrot gun converted into a 9-inch B.L.R. gun on Palliser's system, slightly modified, with the French bore is 'chambered' very slightly. The gun weighs about 13¾ tons. No velocities are reported.

EXTRACTS FROM TABLES I

Showing Particulars of (? proposed) Krupp's Cast-ste

(Metric figures are reduced t

	12 c/m., 4¾-inch		15 c/m., 6-inch		17 c/m., 6¾-inch		20 c/m., 7¾-inch		21 c/m., 8¼-inch	
	30 calibres in length	35 calibres in length	30 calibres in length	35 calibres in length	30 calibres in length	35 calibres in length	30 calibres in length	35 calibres in length	30 calibres in length	35 calibres in length
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Calibre . .	4·72	4·72	5·86	5·86	6·77	6·77	7·87	7·87	8·24	8·24
Length, total .	141·7	165·3	175·9	205·5	204	237·7	236·2	265·6	247·2	278·5
,, of bore .	128·9	152·5	159·4	189	184·8	218·7	213·5	253	223·2	264 5
	cwt.	cwt.	cwt.	cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.
Weight of gun .	39·6	44·8	82·6	93·5	6 11	7 7	10 16	12 6	12 6	13 14
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
,, of steel shell .	44	44	85	85	132	132	209	209	236	236
,, of battering charge	19·8	19·8	37·4	37·4	57·3	57·3	88	88	99 2	99·2
	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.
Muzzle velocity .	1,886	1,985	1,886	1,985	1,886	1,985	1,886	1,985	1,886	1.985
	f. tons	f. tons	f. tons	f. tons	f. tons	f. tons	f. tons	f. tons	f. tons	f. tons
Energy, total .	1,088	1,204	2,094	2,317	3,265	3,612	5,164	5,722	5,877	6,503
,, per ton of gun	544	530	508	492	493	489	478	467	478	474
Penetration into iron:	in.	in.	in.	in	in.	in.	in.	in.	in.	in.
At muzzle .	9·25	10·03	11·6	12·4	13·3	14·5	15·9	17	16·5	17·7
At 1,000 yards	6·7	7·28	8 8	9·6	10·6	11·6	13	14·1	13·7	14·7

RY'S 'NAVIES OF THE WORLD.'

ast and Naval *Guns of* 30 *and* 35 *Calibres Length.*

nearest English equivalents.)

24 c/m., 9½-inch		26 c/m., 10¼-inch		28 c/m., 11-inch		30½ c/m., 12-inch		35½ c/m., 14-inch		40 c/m., 15¾-inch	
30 alibres in length	35 calibres in length	30 calibres in length	35 calibres in length	30 calibres in length	35 calibres in length	30 calibres in length	35 calibres in length	30 calibres in length	35 calibres in length	30 calibres in length	35 calibres in length
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
9·44	9·44	10·23	10·23	11·02	11·02	12	12	13·97	13·97	15·74	15·74
73·3	330·7	308	358	331	386	360	421	419	488	473	551
55·1	292·3	276·3	327·5	297·6	352·7	323·6	384·6	374·4	443·2	412·2	500
ons cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.	tons cwt.	t. cwt.	t. cwt.	t. cwt.	t. cwt.
18 12	21 2	24 10	27 11	32 11	36 11	42 1	47 10	66 10	75 0	95 5	107 7
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
352	352	452	452	562	562	725	725	1,157	1,157	1,631	1,631
143·3	143·3	183	183	227	227	291	291	463	463	650	650
f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.	f.s.
1,886	1,985	1,886	1,985	1,886	1,985	1,886	1,985	1,886	1,985	1,886	1,985
f. tons	f. tons	f. tons	f. tons	f. tons	f. tons	f. tons	f. tons	f. tons	f. tons	f. tons	f. tons
8,714	9,634	11,105	12,334	13,869	15,337	17,894	19,811	28,554	31,613	39,370	44,558
468	456	453	446	425	419	425	419	425	419	415	414
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
18·7	20	20·27	22	21·8	23·6	23·8	25·5	27·7	30·1	31·1	33·6
15·7	17·1	17·5	18·8	18·8	20·4	20·8	22·2	25	26·9	28·1	28·7

CHAPTER III.

TORPEDOES AND TORPEDO-BOATS.[1]

Section I.—*Historical Account.*

COMMENTING on the fact that the torpedo, in a form somewhat resembling that in which it is often used at present, was invented more than a century ago, Admiral Porter, of the United States Navy, says:—'There is no implement of warfare that has made so little progress, or about which there are so many conflicting opinions. It is only since 1861 that it has been generally adopted as an engine of war. But now it is used by the navies of the world; and at this moment no nation can afford to ignore the torpedo either as an offensive or defensive weapon.'

The history of subaqueous warfare can be carried back to a very remote epoch; but the tactics then resorted to bore but little more resemblance to those employed in connection with the modern torpedo than did the manœuvring of the ancient galley bear to that of the ironclad of the present day. The designation torpedo as applied to the modern submarine explosive apparatus is derived from the dis-

Origin of the designation Torpedo.

[1] AUTHORITIES.—Admiral Porter, U.S.N., in *North American Review*, September and October, 1878. L. G. Daudenart, *La Guerre sous-marine* (*Conférences Militaires Belges*); Brussels, 1872. F. von Ehrenkrook, *Geschichte der Seeminen und Torpedos*; Berlin, 1878. F. von Ehrenkrook, *Die Fisch Torpedos*; Berlin, 1878. Lieut. Commander Barnes, U.S.N., *Submarine Warfare*; New York. *Journal of the Royal United Service Institution*; London, 1878. *Torpedoes and Torpedo Warfare*; by C. W. Sleeman, Portsmouth, 1880. C. W. S. Sleeman, Ottoman Navy, in *Engineering*, November 29, 1878. Hobart Pacha, in *North American Review*, December 1878. *L'Année Maritime*; Paris, 1878. Admiral Brommy and Commander von Littrow, *Die Marine*; Vienna, 1878. *Notes on Torpedoes*; *Engineering*, 1878. C. Huët, Capitaine du Génie, *Les Mines sous-marines dans la Défense des Rades* (*Conférences Militaires Belges*); Brussels, 1875. Ferdinand von Attlmayer, *Ueber den Seekrieg*; Pola, 1878. *Mittheilungen aus dem Gebiete des Seewesens*, vols. vi. and vii.: Vienna, 1878. *Revue Maritime et Coloniale*; Paris, 1878. *Edinburgh Review*, October 1877. *Illustrated London News*, *Times*, *New York Army and Navy Journal*, *Engineering*, *Iron*, *Engineer*, *Scientific American*.

tinguished American, Fulton. In the latter part of the eighteenth century, during the war of the American Revolution, David Bushnell, a native of Saybrook (now Westbrook), in the State of Maine, conceived the idea of destroying the British ships of war which were employed upon the coasts of North America, by exploding gunpowder beneath their bottoms. In course of time he constructed several submarine explosive machines of different kinds, with which he not only experimented, but which he also repeatedly tried in practice against the enemy. His most important invention was that of a submarine boat, by means of which charges of gunpowder could be affixed to the bottom of a hostile ship by the insertion of a screw into some portion of the latter's structure. He built this 'diving boat' in 1773. The deck of the boat was made watertight and highly curved, so that the craft had something of a cylindrical form. She was furnished with look-out holes in all directions, some of which served as man-holes for the purposes of embarkation and disembarkation. A pump, which was worked by the foot, regulated the introduction of the quantity of water, as indicated by a gauge, which was necessary for the immersion desired. The motive-power consisted of two screws worked by hand and placed one under the other. The propeller was a horizontal screw, whilst the second screw regulated the descent of the boat beneath, and her ascent to the surface of the water. The water admitted could be expelled by a force pump, so that the boat might rise to the surface to renew her stock of air.

Bushnell's early operations.

After the lapse of nearly twenty years, Bushnell's ideas were again taken up by Robert Fulton, one of the inventors of the steamboat. He constructed for the French Government a submarine boat, with which, in the harbour of Brest, in July 1801, he made several trips under water, remaining sometimes fully an hour beneath the surface. His 'plunging boat' was somewhat similar to that of Bushnell, and was called by him the 'Nautilus.' Propulsion and steering were provided for by the movement of two horizontal and parallel screws. The boat could be made to sink or rise in the floating medium by working a vertical screw. The torpedo consisted of a copper case capable of containing from 80 to 100 lbs. of gunpowder. To this was attached a gun-lock, which could be fired at any required moment. The lock was in connection with a line sixty feet long, led through a block secured to the side of the boat. To attack and blow up an enemy's vessel this line was bent to a kind of harpoon. The boat was then directed towards the ship attacked, and, when near enough, the harpoon was launched so as to stick in the hull of the enemy. At the expiration of an interval of time

Fulton's inventions.

previously resolved on, which was measured by a clock-work arrangement, the lock was set in action and the explosion took place. The torpedo could also be employed against vessels at anchor, advantage being taken of the current to bring it into contact. It was further arranged so as to be sunk twelve or fourteen feet below the surface of the water, and when so used was fitted with a catch, which could be freed on the slightest shock and so cause an explosion.

Electrical ignition of submarine explosives.

In the year 1839 the wreck of the ill-fated line-of-battle ship 'Royal George,' which had lain at the bottom of Spithead Roads for upwards of half a century, was blown up by General Pasley by means of a submarine mine ignited by electricity, insulated cables being laid under water to the explosive. In the early part of 1841 a Swede, named Nobell, offered to the Russian Government an invention, the object of which was to blow up ships by submarine mines ignited from the shore. Experiments with his invention were carried out in a small lake near St. Petersburg, and were witnessed by the Grand Duke Michael and many officers, but were kept a secret from the public. Nobell succeeded in blowing a small vessel into the air by means of a mine laid in the lake and ignited from the bank. The invention had thus established itself, and a sum of 40,000 roubles (equal at the then rate to nearly 6,000*l.*) was paid to the inventor as his reward. Some of the mines afterwards laid down in navigable waters during the Crimean War were probably on Nobell's plan. In 1841 Colonel Samuel Colt, the inventor of the revolver-pistol, after having made some unreported experiments dating from 1829, devised a means of producing explosion under water. His ideas avowedly owed their origin to Fulton's projects. The progress of science and the arts in the interval, which had elapsed since Fulton's time, enabled him to obtain much more perfect apparatus. Having shown that it was possible to explode charges of gunpowder under water by the aid of the electric current from a considerable distance, he publicly ignited a mine in New York harbour in June 1842 with a galvanic battery. In the following year he blew up, by the same means, the hull of the old gunboat 'Boxer,' and in the month of August of that year, in the presence of several persons of distinction, he destroyed on the River Potomac an old schooner from a distance of five miles.

The Sleswig-Holstein war, 1848–50.

The first instance of the use of the modern subaqueous explosive mine as an obstruction of channels in war occurred during the Sleswig-Holstein war of 1848–50. From that epoch dates the real introduction of submarine mines and explosive obstructions. The merit of the invention, or more correctly of its practical application,

belongs to Professor Himly, of the University of Kiel. The professor had no knowledge of the previous attempts of Bushnell, Fulton, and Colt in the same direction. It being expected that the Danish fleet would attempt to enter the harbour of Kiel and bombard the town, the professor suggested that a defence might be created by means of a line of mines laid across the harbour. He received from the provisional Government of Sleswig-Holstein the requisite permission to carry out his ideas. For mine-cases he used casks of considerable size, strengthening them with iron hoops, and making them watertight with pitch and tar. Outside all were large watertight bags made of hemp and india-rubber. The cases contained not less than 300 lbs. of gunpowder, and were anchored with a stout cable and heavy iron weights thirty feet below the surface of the water. As the casks were not completely filled, they were loaded with weights, so as to diminish their tendency to float. The ignition of the fuse was due to a galvanic current, with an arrangement, which is still retained, to cause the incandescence of a platinum wire. In its details this fuse had much similarity to those now in use. The conducting cable was divided, and both ends were stuck through a block of wood and again joined by a platinum wire. This was covered with sporting powder and the whole encased in paper. Professor Himly used the water as the return conductor of the galvanic current. For this reason an end of the cable was led out again through the cask, and terminated in the water with a large zinc plate. At the firing station a similar plate was placed in the water in connection with the galvanic battery. Each mine had its own battery of about twenty-four elements. Of these the following kinds were employed:—

1st. Amalgamated zinc and copper, with diluted sulphuric acid as electro-motive liquid. The cells were ordinary beer mugs.

2nd. Platinised lead and amalgamated zinc with dilute sulphuric acid. The cells were gutta percha boxes.

The batteries were arranged as immersion-batteries, *Tauchbatterien.* On the approach of the enemy the metals were to be immersed, a special apparatus being intended to close the circuit. The cable consisted of copper wire insulated with gutta-percha. The mines were laid in the inner harbour between the dockyard bridge at Düsternbrook and the mouth of the Schwentine, and were anchored chequerwise. The firing station was in a room of the old 'Kurhaus' of the Düsternbrook sea-bathing establishment. The method of indicating the moment of a ship's arrival within the effective range of the mines was primitive. The position of each mine was shown

by a small float immediately above it. Professor Himly was to look out from Düsternbrook across the harbour, whilst a man, proceeding in a boat towards the enemy, was to signal, by firing a pistol, the particular mine in the row towards which the ship was steering. At the proper moment, the circuit in connection with the mine thus indicated could be closed by the professor himself. These torpedoes were never actually used. One was picked up in 1873, and, considering that it had been twenty-five years under water, it was found to be in a remarkably perfect condition.

Bauer's submarine boat.

During the continuance of the Sleswig-Holstein conflict, a submarine torpedo boat was built at Kiel, with the object of blowing up the Danish ships of war lying in the Sundewitt. The designer was a non-commissioned officer of the Bavarian Artillery named Bauer. This vessel was never employed. The preparations for a submarine attack were scarcely completed when the Danish ships were compelled to put to sea, in order to avoid being frozen in. On February 1 the boat was tried experimentally and failed. She was 'about the size of a yacht,' and in the after-part had a screw fixed horizontally. At the fore end was a sort of tube with round windows and a hatch to permit the entrance and egress of the crew. Attached to this were gutta-percha gloves with which the person manœuvring the boat might fix the torpedo under the enemy's vessel. The ignition of the charge was to be effected by a voltaic battery. The sides were formed of cast-iron plate, but these as well as the pumps appear to have been deficient in strength.

Crimean War, 1854–56.

Submarine mines were largely employed during the Crimean War for the defence of the Black Sea and Baltic coasts. At the capture of Yenikalé the Allies found an old vessel laden with mining materials and galvanic apparatus. The latter were numbered, and—as certain of the numbers were wanting—it was concluded that some mines had been already laid in the Channel. Off the coast of the Black Sea two kinds of mines were used:—

1st. Mines to be exploded by contact with a ship. These were anchored, and kept at a depth of seven feet below the surface of the water.

2nd. Mines to be exploded by an electric current put in action from the shore. These were laid at the bottom of the sea in shallow places.

In the first class of mines Jacobi's system of ignition, described hereafter, was adopted. The fuse of the electrical mines consisted of a small box or glass bottle filled with powder, in which the ends of the conducting wire were inserted with a pointed cylinder of carbon

at each extremity, ·02 of an inch apart. The explosion of the powder followed on the passage of the electric spark from one carbon point to the other. An endeavour was made to ensure the action of this fuse by the insertion of a quantity of sulphide of antimony, which is highly explosive. In 1854 the straits which lie opposite Cape Paul and the town of Yenikalé were obstructed by sinking a number of vessels. In the spring of 1855 these obstructions were strengthened by the addition of under-water mines. With this object forty such machines were sunk opposite Cape Paul in two lines checquerwise. A similar plan was adopted at Yenikalé itself, and twenty mines were laid down to defend the roadstead of Kertch. The movements of the ships of the Allies were not in the least hindered by these obstructions, their failure being attributed by General Todleben to the imperfect manufacture of the mines with the limited resources available in the neighbourhood.

Near Cronstadt and Sweaborg, and other parts of the Gulf of Finland, a considerable extent of the navigable water was undermined; and mines were sunk at many other spots in which it was thought possible that the Allies might anchor. The mine-cases in use in the Baltic were of pyramidal or cubical form, made of iron plate, and loaded with from 70 to 75 lbs. of powder. The igniting arrangement was invented by Professor Jacobi, of St. Petersburg. It was intended to act on contact. By the shock of a ship running against the mine a glass vessel filled with sulphuric acid was shattered, and the acid being poured over chlorate of potash, an explosion was produced. The mines were of three descriptions:—

1st. Pyramidal cases, the point of which was turned downwards, with the glass fixed on top in the centre of the cover. This was to be shattered by the blow given by a passing ship to a cap, which stood above the edge of the case, and reached to the other side of the glass.

2nd. Cubical mines with two cases, one within the other, the space between which was filled with pitch. On the top a piece of board rested on four slender supports. A blow given to the board broke the supports, and the board itself shattered the glass containing the acid.

3rd. A tube of glass containing sulphuric acid was placed inside a second tube of thin lead, and laid horizontally on the mine case on two small stout blocks. On contact with a ship the leaden tube was bent and the glass broken, when the acid ran down through a channel to mix with the other ingredient.

It should also be mentioned that during the Crimean War the idea

Russian offensive torpedoes, 1856.

of employing submarine torpedoes offensively had also been hit upon. In the year 1856 the Russian General Baron von Tisenhausen proposed that the allied squadron, which had bombarded the fortress of Kinburn and was afterwards frozen up in the Dnieper Liman, should be attacked with torpedoes. From experiments carried out in Nicolaieff harbour good results were anticipated, though—for what reasons it is not known—an actual attack upon the Allies did not take place. Although the Russians obtained no direct results from the employment of their submarine mines, they believed that the moral effect of them was considerable. It was supposed by them that the explosion under the 'Merlin' and 'Firefly' had caused a great dread of these mines throughout the French and English squadrons, and that anxiety on account of torpedoes had paralysed the undertakings of the admirals. The slight effect of the explosion of the Cronstadt torpedoes on the 'Merlin' and 'Firefly' was clearly owing either to the charge of powder being too small, or—as is more likely—to the cases not being quite watertight, so that some of the gunpowder, after long immersion in the water, became damp. The positions in which the mines were laid down, were not selected with judgment. They should have been within range of the fire of the coast batteries, which might have easily prevented the fishing up of the apparatus. 'The English and French, whenever their fleets were employed in the neighbourhood of the coast, always sent boats in advance of the ships to fish up the torpedoes. The Russians, on their part, were astonished at the skill which the allied seamen speedily acquired in removing these obstructions.'[1]

Austrian submarine defences of Venice, 1859.

The Austrians used submarine mines in the war of 1859 to defend the entrance of the Malamocco at Venice. They contained 4 cwt. of gun-cotton, and were submerged to a depth of twelve feet below the surface of the water. They could be exploded by electricity. As tested by experiment, the effect of the explosion extended over an area of about four fathoms radius. To indicate the moment of a ship's coming within the circle of effect, Colonel Baron von Ebner, of the Austrian Engineers, devised a very simple camera obscura. This was placed in a tower-shaped building having an uninterrupted view of the channel which was mined. The camera itself had darkened walls and a single aperture, in which a lens was fixed. The lens cast the image of the neighbouring harbour on a large prism fixed opposite, which reflected it on to a sheet of glass of corresponding size underneath. The mirror lay on a kind of desk, which contained a powerful galvanic battery. . .Whilst the mines were being laid down, the places in which they were moored were marked upon the glass plate, a small circle

[1] Von Ehrenkrook, p. 27.

indicating the effective area of each. As soon as the reflection of an approaching ship coincided with one of the marks on the glass plate showing the position of a mine, the ship herself was within range of that particular mine. The circuit could be closed, by an observer in the camera, by pressing down a key. Keys, with numbers corresponding to those of the different mines, were arranged like a piano keyboard on the desk. As the image on the glass plate clearly indicated the position of the mines, it was not necessary to have recourse to buoys to ensure their subsequent recovery. An insulating conducting wire led from each to the firing station. These apparatus, which were in many respects highly practical, were given up altogether at a later period of the war. On dark nights, in the smoke of guns, and during fogs—when it was of the utmost importance that they should prove efficient—their effective action could not be depended upon.

Towards the conclusion of the war efforts were made to improve the mining *matériel*, and an observing instrument called the toposcope, invented by the Archduke Leopold, Inspector-General of Engineers, was introduced in the place of the camera obscura. This was provided with a moveable spy-glass, a fixed spy-glass being put up at one of the two observation stations. The torpedoes were in alignment with the latter and were anchored in a row. As soon as an enemy's ship came upon this line, a firing machine at one station was set in action, and the mine, upon which the return current was directed from the first station by aid of the toposcope, exploded.

Chinese submarine mines in the war of 1857–58.

In our war with the Chinese in 1857–58 the latter made use of torpedoes to defend the streams in the neighbourhood of Canton. They were usually loaded with 3,000 lbs., the charges being sometimes reduced to 1,000 lbs. of gunpowder. Various explosions actually occurred, but no damage was done to the English ships, the mines having been in general discovered by look-out boats. The plan of these mines was somewhat as follows:—The case consisted of a hexagonal watertight envelope divided into three divisions. In the middle was the igniting arrangement, and both the others were filled with powder. The central part was closed by a cover, with an aperture through which a knob protruded. As soon as this was knocked off, water was admitted, the igniting mechanism was set in motion, and in a short time the explosion ensued.

American War of Secession.

The most celebrated instances of the employment of torpedoes, both offensive and defensive, occurred in the American War of Secession. Very numerous and very full accounts of the results of the use of the weapon in that conflict have been published in this country

and elsewhere, and no period of the history of submarine warfare has been more frequently dwelt upon. It is not too much to say that it was during the struggle between the Northern and Southern States that the importance of the new tactics first became generally known. Without going again over a story which has been repeatedly told, a few notices of the results of the adoption of submarine tactics on a large scale by both belligerents should be noted in the present historical sketch.

On the side of the United States, seven monitors and eleven wooden vessels were totally destroyed by submerged torpedoes, whilst actively engaged against the enemy. Several other vessels, ironclad and wooden, were temporarily disabled, and during the same operations not a ship of any kind was lost, and but few materially damaged by the heaviest artillery up to that time ever employed in actual warfare.[1] On the other hand, two years of the war had passed before the Confederates made systematic use of the torpedo, and it was during those two years that the navy was most actively and successfully engaged in waters affording every opportunity for its advantageous employment. One solitary instance of the daring and successful use of the torpedo occurred at this period. Lieutenant Cushing accomplished the destruction of the Confederate iron-clad 'Albemarle,' which had become the 'terror of the Sounds,' and threatened to drive the Federal vessels before her. The torpedoes used were of various kinds, including stationary electrical, and contact mines, and spar torpedoes used from steam-propelled boats.

Danish war of 1864.

In the campaign of the German States in Denmark, in the year 1864, when the entrenchments at Duppel had fallen and the Elbe Duchies had been occupied, the Danes were obliged to consider how best to oppose the passage of the Prussian troops into Alsen and Fuhnen. It was determined to have recourse to torpedoes, and the defenders sought to plant them in the waters of those parts at which attempts to cross seemed most likely. On the coast of Fuhnen powerful electric mines were laid down, but we have no exact knowledge of their construction. In Alsen, near Sondeburg, contact mines were employed, thus rendering impassable those parts of the straits which could be navigated by boats, which were the only means available for the Prussians. The contact fuse was very simple. The case consisted of a glass vessel, which, as a security against accidents, was protected by a wooden box. The latter was about twenty inches long, the same in breadth, and about two feet deep. In order to keep it at the proper depth, the charge only half filled the vessel. It consisted

[1] Barnes, *Submarine Warfare.*

of 22 lbs. of powder and was limited to this amount, the mines being intended solely as a defence against boats. The glass vessels were closed with cork and wax, and rendered watertight by an outside coating of asphalte. These mines were anchored with stones along the shore, from six to twelve feet apart, and from three to six feet under water. A glass tube reached to the surface of the water, which caused ignition on being fractured by contact with a boat. In this the fuse was thus arranged:—The end projecting above water was hermetically sealed and passed through the cork stopper well into the case. At the bottom it was bent upwards, made broader, and covered with an india-rubber bag containing loose powder. In the bend was a quantity of petroleum, in which floated from three to five lumps of potassium. The petroleum was employed to protect the potassium against unintentional ignition, but when it was made to act it would increase the flame. The lower end of the tube was closed with a stopper of blotting-paper, the ends of which projected to some distance above the sides of the tube. As soon as the shock of a heavy object broke the glass and filled it with water, the petroleum, being the lighter, rose to the paper and was absorbed by it, whilst the heavy lumps of potassium remained lying at the bottom and came into contact with the water. The potassium then decomposed the water, and, by combining with its oxygen, formed oxide of potash, and thus ignited the petroleum. These fuses had one great disadvantage: at low water the tubes were so much above the surface that they could easily be discovered by the enemy. With the exception of one boat destroyed after the Danes had evacuated Alsen, no damage was done by these torpedoes.

Paraguayan war, 1866.

During the war between the Empire of Brazil and her allies and the Republic of Paraguay, submarine explosive defences were much used. In the early part of 1866 Lopez retreated to the country lying between the Parana and Paraguay rivers, in which the only attack he had to fear was one that might be made from the south along the line of the river. The allied generals were unable to advance to the positions chosen on the Paraguay without the active co-operation of the fleet. The supply of the army in this roadless, marshy, and often impassable region was only practicable by water. The Paraguayans endeavoured to prevent the advance of the ships by obstructing the channel. In May 1866, Admiral Tamandarè, of the Brazilian Navy, had under his command in the neighbourhood of Fort Curuzú, below Curupaity and Humaita, a fleet of four ironclads and sixteen wooden corvettes and gunboats. To prevent the advance of this force, without the support of which the allied army could not exist, President Lopez strengthened the works of Curupaity, and had

obstructions and torpedoes placed in the river. After an ineffectual bombardment of the fortress the ships retired behind the island of Palmas; and whilst lying there two vessels, the 'Bahia' and 'Belmonte,' were struck by torpedoes which had been sent floating down the river from Curupaity. Neither exploded, and it would seem either that the mechanical arrangement for igniting the mine was not quite ready for action, or that the torpedoes had been so long in the water that they had become ineffective. They consisted of a zinc cylinder, which contained the charge, inside two other cylinders. The fuse was a glass capsule filled with sulphuric acid, and surrounded with chlorate of potash and white sugar, the whole being covered with cotton. The fuse itself was fixed in a perforated cap, to be broken on striking against a heavy object. From this it seems that the fuses were of the 'contact' kind, on Jacobi's principle. On September 2 the ironclad 'Rio de Janeiro' was ordered to advance and engage the fort of Curuzú. On arriving at a suitable position she struck against a submerged torpedo. She was suddenly lifted up into a boiling whirlpool, broke in two amidships, and sank quickly to the bottom. Of the crew of 115 men, 53 were killed by the explosion, while others were drowned or shot by the enemy. The torpedo was either floating about or anchored in the stream; it consisted of a conical wooden case lined with zinc, which contained 300 lbs. of gunpowder. This was enclosed in a second case of the same form, also lined with zinc, and there was an air space between the two. The fuse was the common sulphuric acid fuse, and was ignited by pressure on a bar immediately above it. When the passage of Curupaity was forced in August of the following year, though it was known that the channel was extensively mined, there was not a single explosion. This was attributed by the Brazilians to the exceptionally high level of the water in the river, which enabled the ships to pass in safety over the torpedoes.

Austro-Prussian war, 1866.

In the war of 1866 torpedoes were used only by the Austrians, and on the coasts of the Adriatic. The central scientific military committee determined in April 1866 that not only the channel of Malamocco and the two other approaches to Venice, the Lido and Chioggia, but the most important harbours on the Istrian and Dalmatian coasts, viz. Pola, Lissa, Gravosa, and Cattaro, should be defended by torpedoes. Baron von Ebner invented one which combined the advantages of the electrical and the contact systems. Explosion was to follow on shock by a ship, but only if the defender desired it. The apparatus was very simple. A hollow cylindrical case of sheet iron, 3½ feet in diameter and three feet in height, formed the torpedo.

It contained an inner cylinder loaded with 3 cwt. of fine grained powder. Nine percussion knobs projecting above the cover of the torpedo received the shock by means of bars on a horizontal toothed wheel, the axis of which carried the electric fuse fixed watertight in the bursting charge. The turning of the toothed wheel puts the fuse in metallic contact with the electric wire introduced through the bottom of the torpedo; at the same time, by a special arrangement, it changed the voltaic current into an extra current with higher tension, and therefore more suitable for inducing ignition. With that object the current from the battery, after first passing through a relay to the circuit closer, came to the firing station, where all the cables ran together, and thence, when being put in action, to the united cables of the line of torpedoes. In addition, at the firing station there was an arrangement controlling the insulation of every wire and torpedo, and the number of any torpedo that had exploded could be ascertained, and its cable, which might divert and weaken the current, could be disconnected. Two lines of these torpedoes were laid down at Pola. The electric-contact mines floated ten to twelve feet below the surface, and were anchored with an anchor of the shape of a segment of a sphere. The electric-observation mines in the channels floated thirty feet below the surface. The system of placing the several kinds of mines in the channels of the Austrian harbours was very elaborate and was carefully carried out; but no opportunity occurred of trying its efficacy against the enemy's ships.

Franco-German war, 1870.

The history of torpedo defence in the war of 1866 was in great measure repeated in that of 1870 between France and Germany. When the war began a very small amount of stores was at hand in the latter country; and in the early days of the contest old beer barrels and similar articles were made use of, as the cases of contact torpedoes on Jacobi's system, with which to defend the most exposed parts of the coast. Pear-shaped cases of iron were introduced as soon as possible. The torpedoes used by the Germans during the war are thus described:—1st. Contact torpedoes with Jacobi fuses. 2nd. Electric torpedoes with platinum wire fuses, to be fired by observers provided with telescopes on shore. The charge was 10 cwt. of powder, and they were anchored with stones or mud anchors. 3rd. Harvey torpedoes of the usual pattern. 4th. Spar torpedoes worked from boats. As in the Adriatic four or five years before, on no occasion were they really tried against an enemy.

Russo-Turkish war, 1877.

In the war between Russia and Turkey in the year 1877 several important torpedo expeditions were undertaken by the navy of the former Power. The first attack made by the Russians was 'on the

night of May 12–13 at Batoum. They had equipped for the purpose a hired iron screw steamer, the "Constantine;" which did not steam more than ten knots. The crew consisted of 150 men and four officers, exclusive of the pilot, engineer, and doctor. The armament consisted of torpedoes and 4-pdrs. and four fast torpedo boats. She left Poti on the evening of the 12th for Batoum. At 10 P.M. she was off the roadstead at seven miles' distance. She despatched her four boats, which were each commanded by an officer. These boats were well constructed, painted sea-green, had high speed, answered their helms readily, did not betoken their approach by the noise of their engines, and, from their small size, were but poor targets for an enemy's guns.' Arrived in the roads one boat, which was ahead of the others, came across a Turkish ironclad on the lookout. The officer in charge of the boat succeeded in placing the towing torpedo with which she was armed under the ironclad's stern, but when the electric firing key was pressed no explosion took place, owing, it seemed, to the stripping of the insulation from the wires, which had fouled the boat's screw. The Turks were now on the alert, and the boats had to retire.

In the second affair of the night of May 25–26 four Russian boats, armed with spar torpedoes, attacked a Turkish squadron of two armoured gunboats and 'an ordinary two-funnelled steamer' on the Danube. A carefully arranged plan of mutual support was devised amongst the officers commanding the boats. At 2.30 in the morning they came near the Turkish vessels. A boat, commanded by Lieutenant Doubasoff of the Russian Navy, had such noisy engines that she had to be stopped several times to avoid alarming the enemy. 'At last, arriving about 135 yards from the latter, Lieutenant Doubasoff turned on the blast, stoked up his fires, and steered for the gunboat "Seifé." At about 65 yards from the ship the hail of the Turkish sentry was heard. Doubasoff's reply betrayed him; the Turks were on their guard, for the sentry fired his rifle, which was repeated from the neighbouring ships. Three successive misfires of one of the guns on board were heard. Disorder spread through the "Seifé;" the men ran hurriedly on deck firing here, there, and everywhere; the crews of the turret guns, which commanded the deck, rushed to their posts. During this time the torpedo boat was approaching. Sixty yards were quickly passed over, though, allowing for the current, she was steaming only four knots. The officer steered for the port deckhouse, so as to shelter himself as much as possible from the fire of the after guns, as well as from that of the turret guns, and also to injure the "Seifé's" screw and rudder. It may be

mentioned that the precaution had been taken of keeping steam in readiness. The torpedo, on a spar rigged out ahead of the boat, touched the ship between the stern and 'midship part a little before the stern post and exploded. The water rushed into the sides of the monitor, the waves washed over the boat; many fragments were thrown up to a height of 120 feet. The monitor's stern began to sink. At this moment Lieutenant Shestakoff, in a second boat, came up and exploded another torpedo a little abaft the turret, the stern of his boat actually touching the monitor. 'The effect of the explosion was tremendous. Both boats had some difficulty in getting clear; one was nearly filled with water, and the screw of the other was fouled by pieces of the wreck. The vessel destroyed was of no great size, being intended for river service. She mounted two 12 c/m. (4¾ inches) Krupp guns, and had a complement of sixty officers and men.'

An unsuccessful attempt was made on some Turkish ships lying off Sulina on the night between June 10 and 11. The boats were in some cases armed with towing, in others with spar torpedoes. One of the former, when in tow, was rendered useless by the wires fouling the screw. The same thing had happened in the affair at Batoum. The Turks were keeping a good look-out, and were defended by obstructions. Another boat, with torpedo spar rigged out, made for one of the Turkish vessels, and on getting close to her exploded the torpedo, but it did no injury to the ship attacked, and the boat herself had great difficulty in escaping. A third boat ran against an obstruction formed of boats and parallel ropes—hammock-girtline or clothes'-line fashion—stretched between them, and there exploding the torpedo was sunk by the fire of the Turks and her crew made prisoners. In the same month of June six Russian steam launches attempting to lay down mines in the Danube were attacked by a Turkish steamer and compelled—in spite of an attempt to explode a spar torpedo under the steamer—to make off. Another attempt was made on December 27 against the Turkish squadron at Batoum with fish torpedoes. Five[1] of these were launched, one of which exploded against a chain, and one, if not more, was picked up on the beach, having failed to act.

During the action between the British ships 'Shah' and 'Ame-

[1] This is the number given by Hobart Pasha. A French writer, Lieut. Chabaud-Arnault, gives an account of a 'third affair' at Batoum in January 1878, in which a Turkish unarmoured steam-vessel was destroyed. Admiral Hobart Pasha makes no mention whatever of this, and his testimony is strongly against the authenticity of the account.

Fish torpedoes used by H.M.S. 'Shah' against the 'Huascar,' 1877.

thyst' and the Peruvian armourclad 'Huascar' in May 1877, a Whitehead torpedo was fired from the 'Shah' at the moment of passing her opponent, 'but the "Huascar" at that instant altered course, turning stern on, and the torpedo failed to reach her; the "Huascar" going certainly eleven knots, and the torpedo having only a speed of nine knots, it could not overtake the vessel. The torpedo's track was observed going direct for about half the distance towards her.'[1]

A remarkable example of the danger incurred by an assailant when making an attack with a spar-torpedo has been reported from South America. A swift Chilian torpedo-boat attacked a Peruvian boat at high speed; and, bringing her torpedo into contact with the latter before the spar was fully rigged out and rushing forward at the same time towards the explosion, was destroyed together with her antagonist.

This may be said to conclude the history of the explosive torpedo in actual warfare.[2] As previously indicated, few details have been given here of the many instances of its use during the American Civil War, those being as well known as any events in naval history. It has rather been attempted to draw attention to less known matters of a similar kind, and to the fact that the use of the torpedo was well understood in other wars. Before proceeding to a description of the several kinds of torpedoes employed at the present day, the following summary of the general results of a recourse to torpedo tactics may be given:—The fish torpedo has been eight[3] times launched in earnest, and always without success. The towing torpedo has been twice tried, and has failed on both occasions. The spar torpedo has succeeded in destroying the vessels attacked—twice in America, in the cases of the 'Albemarle,' and 'Housatonic,' and once on the Danube, in the late war.[4] Defensive stationary torpedoes have in many instances caused the destruction of ships which have ventured within range of them. A late French writer[5] has remarked that a condition essential to the success of these weapons is 'that they should be manœuvred by bold, well-disciplined crews, free from liability to

[1] Letter from a naval correspondent in the *Times*, July 14, 1877.

[2] Two Chilian vessels have been destroyed in the war still (Dec. 1880) in progress in the South Pacific. But both were sunk by incautiously taking possession of deserted boats in which explosive apparatus (*acting above water*) were concealed.

[3] That is, allowing that five were launched against the Turkish ships at Batoum.

[4] Perhaps the case of the Chilian torpedo-boat mentioned in the text, in which both assailant and the boat attacked perished, may be added to these.

[5] *L'Année Maritime*, p. 32.

panic, and composed of men resolutely determined to sacrifice their lives if necessary.'

Section II.—*Various kinds of Torpedoes.*

Torpedo tactics are of such recent introduction into maritime warfare that the definitions and divisions of the different kinds of submarine explosive machines are, as yet, hardly settled. By some authorities torpedoes are divided into two principal classes:—

(1) Moveable torpedoes which can be steered.

(2) Fixed torpedoes, which may be aground, floating at anchor, or drifting at hazard.

Different submarine explosive machines.

In Germany and Austria the divisions are more numerous and the terminology more exact. In those countries torpedoes are described as being in general hollow bodies of cubical, cylindrical, pear-shaped, or some other regular form. They are made of wood, sheet-iron, or cast-iron, and are filled with a bursting charge and provided with a fuse. Strictly speaking, only those explosive machines for under-water attack which reach the object aimed at by their own motion have the name of *torpedoes*. All other explosive arrangements fixed in a particular position, and intended to be put in action on the approach of a ship, are more exactly distinguished as submarine, or under-water *mines*. Sea mines have, therefore, the character of stationary obstructions for the defence of harbour entrances, and such places on a coast as an enemy may select for disembarkation. They are divided into *contact mines* and *observation mines*. In the former, ignition results from the shock of the ship which it is intended to destroy. Contact mines continue in working order always and in all weathers, and, consequently, frequently form the principal portion of submarine obstructions. Observation mines are intended to be ignited from the shore by an observer on the look-out, by means of electricity, at the moment that an enemy's ship passes over them, or comes within their destructive range. To ascertain this moment the camera obscura, or an electric signal, is employed. Observation mines are indispensable where it is necessary to keep open a passage for friendly ships, and at the same time to be prepared with a defence against the enemy.

Thus it will be seen that, taking a very general division of them, torpedoes are either stationary or moving. The former may be fastened to piles, rafts, or any other obstruction, or anchored to weights that keep them submerged to a certain depth when in position. The latter are intended to be used offensively, and may either

float on the water, drifting in obedience to the current or the wind; be attached to a spar or out-rigger to be driven against a vessel by a launch or torpedo boat, be towed so as to come in contact with the bottom of a ship, or be propelled under water by machinery fixed at the point whence the attack is conducted, or—if automatic—in the torpedo itself. The apparatus used for firing is either mechanical or electrical. It includes the simple application of the match, instantaneous explosion by concussion, timed explosion by the employment of clockwork—though this is now rarely, if ever, used—and explosion either on contact or at will by means of electricity. Explosion by concussion may be due to chemical action, to friction, or to percussion. A general idea of the several methods adopted to ensure ignition by chemical means has been given in the historical account in the last chapter.

Stationary torpedoes, or submarine mines, according to mode of ignition.

Following up the division just stated of stationary torpedoes, or mines, into classes according to the method of igniting their charges, we find that German and Austrian authorities enumerate two different kinds.

(1) Those which explode only in direct contact with, or on shock given by, a ship. Their effect is due to the action of fulminating primers, or glass tubes filled with acid, which, on being shattered, induces inflammation of the bursting charge. (2) Those which are made to burst when a ship comes within range of their explosion. The fuse or priming of these forms part of an insulated metallic circuit, the ends of which are brought to a station on shore. Ignition ensues on bringing these ends into connection with the poles of an electric battery at the station, where it can be completely protected. This is called 'closing the electric circuit.' These mines are designated 'electric torpedoes.' They are of two distinct classes:—

(*a*) Those in which the break in the circuit is close to the battery, ignition taking place when the ends of the wire are connected with the poles of the latter.

(*b*) Those which explode at the moment that the shock of a ship closes the circuit, which is interrupted near the fuse itself, the ends of the electric wire being kept connected with a battery placed in security.

Contact torpedoes have the great advantage of bursting exactly at the point intended, but they are not without disadvantages. Sinking them is a dangerous operation, as the tubes containing the acid are easily broken. They must be placed close together. Those, moreover, with fulminating primers are difficult to regulate; either the priming ignites too easily, in which case the shock of light bodies

and even of waves makes it act, or it is not sensitive enough, so that a ship moving slowly can pass over the mine without causing explosion. They are an obstacle to the passage of friendly vessels. When once in position they are no longer under control, and their condition cannot be ascertained. Lastly, an enemy can send objects against them to make them burst prematurely.

Electric torpedoes, when sufficiently submerged, are free from the above disadvantages. Those which have only one break in the electric circuit—in French nomenclature, *à simple interruption*—comprise three parts—the fuse, the charge, and the case, besides the articles necessary for adjusting the electrical connections and the conductors, which enable the operator to control the mine. The ignition of the fuse is due to the well-known fact that when an electric current meets in its course with a substance forming part of the circuit of a lower conductivity than that of the rest of the circuit, there is at that point an increase of temperature due to the accumulation of the electric fluid at higher tension, or, more exactly, to the conversion into heat of a certain quantity of motion. Consequently the ignition of the fuse occurs if the latter is of the substance in question.

'Electro contact torpedoes (*à double interruption*) combine the advantages of contact and simple electric torpedoes. They are inoffensive as long as the ends of the conductors are not in connection with the battery.' They should be submerged so as not to be liable to be touched by light floating objects, but at the same time so that ships cannot pass over them without contact. In general terms their action may be thus described:—The wires are connected with the battery, and the only interruption in the circuit is then at the torpedo itself; the shock of a ship against an arrangement called the 'circuit closer' finally completes the circuit, and the passage of the electric fluid ignites the fuse. *Circuit closers* are of several kinds. An exhaustive series of experiments were instituted by the British Government and carried out in the Medway, with a view of ascertaining the 'merits or demerits of different circuit closers.' They afforded marked proof of the superiority of an arrangement employing no exterior mechanism over that which necessitates the use of external appliances for communicating the blow of the ship to the internal apparatus. The general electrical arrangement is similar in character to Professor Abel's earlier circuit closers, the electric chamber being formed by a fixed brass cylinder passing vertically through the centre of the vessel. Within this cylinder, which is left open at both ends, a moveable brass tube extends vertically through the entire length, its lower extremity working upon a universal joint, while the upper end projects through the

Circuit closers.

top of the vessel and is attached to a strong teak-wood disc resting upon the outer case and projecting slightly beyond its rim. Encircling the upper extremity of the glass tube is a thick india-rubber ring, which serves to hold the whole combination rigid, and by its resistance, varying with its thickness, regulates the force which must be used to close the electrical circuit by reducing the distance between the contact points. The closing of the circuit is accomplished by attaching to the upper end of the moveable brass tube an ebonite collar, which serves to insulate a copper band encircling it; this band is separated by a small space from a corresponding metallic ring attached to a fixed tube, but insulated from it by means of a collar of ebonite. At the lower extremity of the cylindrical chamber two insulated wires are introduced, one of which is soldered to the copper ring surrounding the moveable tube but insulated from it; and the other is connected in like manner to the insulated brass ring attached to the fixed cylinder. It will be easily understood that the effect of a blow on the edge of the external teak disc would be transmitted to the moveable tube, by which means the metallic rings would be brought into contact, and the circuit at that point closed. The arrangement introduced into the torpedoes laid down by the Turks in the late war was invented by Mr. Frost, Superintendent of the Cartridge Department of the Tophaneh Arsenal at Constantinople. It consisted of a cup of fulminate, into which a heavy plunger, with a point roughened to produce friction, would fall on the torpedo being struck. This plunger was suspended by an india-rubber spring, fitting into notches round the upper part of the fuse case, intended to contract on vibration, and so release it. The above detailed description will suffice to explain the action of the circuit closer, of which several forms have been devised.

Torpedo cases. The cases containing the explosive to which the circuit closers are attached differ considerably both in form and general construction, and in the electrical arrangement employed for bringing about the explosion of the charge at the desired juncture. These conditions depend, in a great measure, on the class of explosive that may have been selected for use. The combustion of gunpowder being less rapid than that of gun-cotton, it is necessary to increase the strength of the containing vessel proportionally, hence for the former cases are usually made of from $\frac{1}{2}$-inch to $\frac{5}{8}$-inch wrought-iron plate, while for the latter it is quite superfluous to exceed $\frac{3}{16}$ inch of the same metal. Considerable difference of opinion exists as to the best form of case for containing the explosive. The British Government employs

cylindrical cases having dished ends. For buoyant charges the cylindrical cases are undoubtedly preferable to any yet devised, but as ground mines their advantage is by no means so apparent. The material of which torpedo cases have been constructed has varied greatly. Boxes of tinned iron, carefully riveted and soldered, and double cases of wood strengthened with iron bands and coated with pitch, have been employed by Continental Powers. Sometimes the case is arranged as follows:—An interior wooden box is placed inside one of soldered zinc; the whole is enclosed in another wooden box iron-bound; and a space of five to seven millimètres ($\frac{3}{16}$ to $\frac{1}{4}$ inch) filled with tallow and pitch separates the box from its outer covering. At present sheet iron of a greater thickness than 7 to 15 millimètres ($\frac{1}{4}$ to $\frac{9}{16}$ inch) is not generally employed. Dimensions and shape depend upon the charge used, and also vary according to the service for which the torpedo is intended, and whether it is to be buoyant or aground.

Material of bursting charges. A variety of explosive compounds have been used for the charges of submarine mines and locomotive torpedoes. Gunpowder, as is well-known, is not nearly so powerful an explosive agent as gun-cotton; neither is it so suitable for submarine mining purposes, owing to its liability to become deteriorated by damp, occasioned by possible leakage in the enclosing vessel. Gun-cotton, which is now largely employed, recommends itself for adoption in preference to other explosive compounds on several grounds, the principle of which is its capability of being ignited by detonation whether wet or dry, thus obviating any likelihood of its becoming deteriorated through chance leakage. In some systems the introduction of water caused by the fracture of some part of the apparatus will interfere with explosion. In such cases the employment of combustible liquids, or gun-cotton, dynamite, etc., is preferable to that of gunpowder. Waltham Abbey disc gun-cotton, saturated with 30 per cent. of water, is the only explosive material at present known which seems quite suitable for submarine warfare. Dynamite can produce at least equally destructive effects. But experiments undertaken at Carlskrona by the Swedish Government have proved that the explosion of a dynamite torpedo sets off the others of the same substance which are submerged within a radius of thirty yards. From this it results that the whole system of defence of a roadstead, depending on torpedoes so charged, would be annihilated by the bursting of the first mine, which the enemy would take care to bring about himself. Abel's gun-cotton does not threaten the same inconvenience. Experiments at

Portsmouth have shown that the explosion of a charge of 500 lbs. of gun-cotton leaves intact others of the same material, and even charges of dynamite one hundred feet from the centre of explosion.

Electric batteries and fuses.

For some considerable time great difficulty was experienced in obtaining batteries possessing the necessary requirements for submarine ignition. It was essential that they should be capable under all varieties of temperature of exploding simultaneously in divided circuit twenty-five platinum wire fuses, or such number of these or other fuses as might seem desirable; and that, as in case of war they may have to be entrusted to the hands of men previously unacquainted with them, no great technical knowledge should be required to keep them in order; also that defective parts should be easily discovered and repaired, and the highest degree of constancy guaranteed, as the torpedoes may be in position for months in expectation of an enemy. Further, no porous pots could be employed on account of their liability to fracture during transport, or when in position through crystallisation. This led to the introduction of tension fuses. Here again, however, fresh difficulties were encountered, owing to the necessity of employing cables with very perfect insulation. Although for firing either dynamo-electrical machines or magnetic exploders could be employed, the current induced was so small that the slightest leakage at any of the joints or anywhere along the line sufficed to nullify its action and so prevent ignition. Frictional electric machines supply charges of electricity that would leap any reasonable break in the continuity of the conductor; but, besides smaller defects, frictional electricity has an energetic inductive action on insulated cables lying in the vicinity of its own, which makes it highly dangerous to neighbouring torpedoes, and of course entirely precludes the use of multiple-core cables.

Tension fuses.

In certain cases, as with solitary torpedoes, or where no voltaic battery power is at hand, the magnetic exploders or frictional electric machines recommend themselves for adoption, as being capable of readier transport. They are used in combination with *tension fuses.* One of the simplest of these fuses is Beardslee's. It consists of a cylindrical piece of soft wood, about ¾ inch in length and a little less in diameter, through which two copper nails are driven in a slanting direction, so that while the heads are flush with the wood at one end, and as close together as possible without touching, the points project from the opposite end at some distance apart. To these projecting points the bared extremities of two insulated copper wires are soldered, a piece of soft wax of the same diameter as the wooden cylinder being pressed round the points of junction. A slight groove is filed

across the wooden cylinder between the heads of the copper nails, so as to insure their separation, a little black lead from a pencil being rubbed into the groove. When a current of high tension is passed from nail to nail, the electric sparks ignite, or greatly heat the black lead between, and explode a mixture of very fine grain and mealed powder in a paper-covered cartridge. Professor Abel's and Baron von Ebner's fuses differ from this not only as regards their construction, but in the substitution of certain chemical compounds for the black lead. The fuse composition employed by Professor Abel consists of ten parts of specially prepared sub-phosphide of copper and fifteen parts of chlorate of potash, finely divided and thoroughly incorporated, with the addition of a little alcohol, and then dried at a low temperature. That of Von Ebner consists of equal parts of sulphuret of antimony and chlorate of potash, with a small quantity of powdered plumbago to give conducting power for testing purposes. Abel's tension fuse is most generally adopted wherever electricity of high tension is employed for the ignition of mines or torpedoes. When employed for detonation, fulminate of mercury, enclosed in a cylinder of sheet tin tightly fitting on the fuse head, is substituted for gunpowder, in contact with the priming composition. To fire tension fuses any ordinary form of battery used for working a telegraph line would supply the necessary electro-motive force from a sufficient number of cells, whilst generating a quantity of electricity enough to overcome a fault or leak in the conducting cable. About sixty cells of Daniell's battery are necessary to overcome the resistance of Abel's tension fuses.

Platinum wire. Platinum wire fuses are so simple and easy to make that they became at an early period the favourite mode of ignition. The batteries first used with this fuse have been surpassed, if not in simplicity, in power and constancy by that known as the 'modified Leclanché,' or Silvertown firing battery. The ordinary Leclanché cell consists of a porous pot containing a plate of carbon, which is surrounded by a mixture of gas carbon, and the needle form of peroxide of manganese, the porous pot, together with a zinc rod, being placed in a solution of sal-ammoniac. In the modified Leclanché for the porous pot a felt cylinder is substituted, and for the rod of zinc a cylinder of zinc. The pattern of platinum wire fuses in present use in the British service consists of an ebonite body, about $\frac{1}{2}$ inch in diameter and $\frac{3}{4}$ inch long, through which project the bare extremities of two insulated copper wires forming the 'poles' of the fuse; these extremities are connected by means of a platinum wire bridge, about $\frac{1}{4}$ inch long and $\frac{1}{3000}$ inch in diameter, soldered to

them. A film of gun-cotton is finally placed in contact with the platinum wire and a charge of fine grain rifle powder in a small ebonite covering cap.

Testing.

To ascertain that the mines submerged for the defence of particular places are in working order, arrangements have been made for testing the insulation of the wires and the condition of the bridge of the fuse. If one of the submarine mines has been exploded, it becomes essential that its number should be at once ascertained, in order to disconnect the electric cable lately leading from it. To discover this it is necessary to take a weak battery, put the negative pole to the earth, and connect the positive pole to one terminal of a sensitive galvanometer, to the second terminal of which is connected an insulated conductor. By bringing the extremity of this conductor successively into contact with the series of terminals from which radiate the several electric cables, a current would be sent through each cable in succession, and, on arriving at the terminals connecting the broken cable with the instrument, would pass through the water back to the earth-plate of the battery, the fact being indicated to the operator by the deflection of the galvanometer needle. The weak current employed is sufficient to deflect the needle, but is not powerful enough to ignite the fuse.

A recent and novel application of the telephone has been made in connection with torpedoes of the buoyant class connected with the shore by electric cables. To supplement the usual electric test by sound an ordinary Bell telephone can be enclosed in each torpedo, and be so placed that the vibrating diaphragm is in a horizontal plane. On this are laid a few shot or pieces of metal, which are then boxed in. Every motion of the torpedo causes the shot to shift their position and to make a slight noise, which is heard in the receiving telephone on shore. Should the torpedoes be sunk, they would lie motionless, and the silence of the telephone would indicate their being so. The usual tests can be also applied.

Cables for electrical torpedoes.

The electric cables for torpedo purposes are single and multiple. In the single cable are contained copper wires insulated with vulcanised india-rubber to a diameter of ·24 of an inch, over which a layer of felt or other material is wound. Over the core thus formed a padding of tarred picked Russian hemp is wound spirally, followed by galvanised iron wires, each wire being separately covered either with two coatings of hemp or with tape. Seven single insulated cables have been combined in one external protecting cable, thus constituting a multiple cable. The latter is used to diminish the

number of conductors that would be required were each mine to have its own cable.

The system of protecting a harbour or roadstead, or obstructing a channel, by laying down submarine mines or torpedoes, does not call for explanation in a work like the present. It belongs rather to such treatises as discuss the subject of coast defence. Sufficient allusions to it have been made in the descriptions of the various kinds of stationary torpedoes, or will be found in accounts of experiments at a subsequent page. Submarine mines, in cases in which the hydrographical conditions are favourable to their employment, are more particularly valuable for coast defence in positions where formerly artillery, in combination with obstructions, afforded the only means of keeping the enemy's ships at a distance. Unsupported by artillery, mines, in common with every other kind of passive obstruction, are altogether ineffectual to prevent the approach of a hostile fleet. In some instances, it should be noted, when heavy charges of a violent explosive have been used, the force of the explosion has directed itself against the bottom of the sea. Further experience is required both as to the effect produced by mines of this class on the bottoms of ironclad ships and, especially, as to the exact amount of explosive charge which is necessary, and as to the distance at which the mines will take effect on a ship.

Spar or outrigger torpedoes.

On the re-introduction of offensive torpedo tactics during the American Civil War, the spar or outrigger torpedo was the one chiefly employed for attack. At the close of that war the officers of the United States Navy occupied themselves in improving the weapon, and devising a system of manœuvring it. It is usually attached to the extremity of a spar, or outrigger pole, and is brought into contact with the ship which it is intended to blow up by an ordinary ship's boat or by a special vessel called a 'torpedo boat.' The spar torpedo can be used either by a small steam vessel, in which an attempt is made to approach an enemy's ship unobserved and attack instantaneously at high speed, or it may be used by larger vessels, which are able, by means of their speed and handiness, to make an effective use of such a weapon. The first kind of attack can only succeed against ships which are lying in a harbour or roadstead, or against booms, pontoon bridges, or other stationary objects. Large ironclads can only be struck under circumstances specially favourable to the attack, under cover of night or in the confusion of battle. The spar torpedo boat must go straight at the enemy under the fire of his guns, and within reach of his towing torpedoes if he is provided with such appliances. The attack is like that of a man armed with

a sword against another armed with a pistol. The Turkish vessels in the Danube were, indeed, approached unmolested, and an explosive engine was fixed against their side; and, when an opportunity is patiently sought, it is doubtless possible to direct a torpedo against ships in which the watch is kept with the customary carelessness of the Turks, but this no more proves the superiority of the system than the fact that a dagger will deal a fatal blow at an adversary taken unawares will justify its selection as an ideally perfect weapon.

The following general description will suffice for this class of torpedo. Along each side of the boat there lies a spar between thirty and forty feet long which can be rigged out by a line or tackle fastened to its after end. To the outer extremity of this spar a torpedo is fixed. When the spar is rigged out this end dips deeply into the water. From the fuse in the torpedo electric wires are brought into connection with a battery in the boat in which an operator under cover can close the circuit at will, or—as in more recent patterns—can close one interruption in it, so that the electric circuit may be prepared for final completion on the sharp contact of the head of the torpedo with a vessel's bottom. The ordinary boats of a ship, at first almost exclusively provided for the purpose of employing outrigger torpedoes, have of late been supplemented by the introduction of special torpedo launches propelled by steam, and capable of being moved at a high speed. A description of these boats will be given hereafter. The method of using the weapon is to run close up to an enemy's vessel until the torpedo is in actual contact with the side below the water, and then explode it, the spar being rigged out at a short distance from the boat. When contact is made, the electric circuit is closed either by the operator in the boat or by the pressure of the torpedo against the object attacked.

There are serious objections to the spar torpedo. It is necessary to bring the boat from which it is manœuvred close to the enemy attacked, and there is a consequent liability to be swamped[1] from the violent explosion of the torpedoes. To meet these objections torpedoes have been invented which can be aimed at an enemy from a distance. Of these the 'Whitehead' or 'fish' torpedo is the most important, and the one most generally adopted. Large numbers have been constructed for our own and for foreign Governments, and some have been used in active warfare. These engines were first constructed at Fiume, in Austria, by Mr. Whitehead, an Englishman,

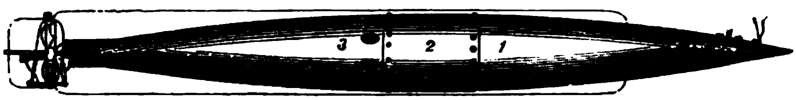
'Whitehead' or 'fish' torpedo.

[1] Allusion has already been made (at p. 134) to the destruction of a Chilian torpedo-boat by the explosion of the very weapon which she had used with success to blow up a Peruvian antagonist.

at the end of 1860. The idea first originated with Captain Lupis, a commander in the Austrian service. Externally the torpedoes closely resemble a cigar in shape, or, to some extent, a fish, whence their name. Commander Sleeman, late of the Turkish Navy, in his work on torpedo warfare divides them into classes, the 'Whitehead' proper and the 'Woolwich,' or that made at the Royal Arsenal. Of the former he specified three kinds and of the latter one. The Woolwich torpedoes have a length of 14½ feet and a maximum diameter of 14 inches, and are propelled by two screws. Some are 19 feet long[1] with 16 inches maximum diameter, and a speed of over 25 knots an hour can be maintained for a distance of 200 yards. The weight, including the bursting charge, varies from about 500 lbs. to 750 lbs. The specific gravity is somewhat less than that of water, so that the torpedo floats, or rather is immersed only to a certain depth beneath the surface. This depth can be regulated as required.

The speed of the torpedoes used in the British service and the — Speed of Whitehead torpedo.

Fig. 84.



THE WHITEHEAD, OR FISH TORPEDO.

The Nos. 1, 2, 3, show the positions of the principal compartments. The general shape and appearance of Whitehead torpedoes of all classes are shown in the above figure; trifling alterations in some of the details of the exterior have been made from time to time.

ranges which they attain are given in Commander Sleeman's work already cited (at p. 134). The figures for those employed by foreign Powers have been given as follows:—

At 36 feet	per second	the range is about	200	yards
„ 27	„	„	800	„
„ 22½	„	„	1420	„

Improvements are continually being made in the weapon, especially in its motive power, so that both range and speed may have been increased, but the present account has been compiled with as near an approach to accuracy as it is possible to attain. The bursting charge of the Whitehead is from 33 lbs. to 55 lbs. of gun-cotton. The weight of the charge is limited by the size of the torpedo. A mere graze against a hostile object suffices to cause explosion.

We proceed to give a general description of the Whitehead torpedo. The mechanism is contained in a long cigar-shaped case of — General description of mechanism.

[1] Some have been made as long as 22 feet.

thin steel built in sections well screwed together. The metal is about $\frac{1}{16}$ of an inch in thickness. In the head is the charge to be fired by the forcing of a roughened pin into a cap of fulminate on the torpedo striking against anything after it has been set in motion. The gun-cotton, when used, is pressed into discs of various diameters, which are then placed one on another to form a cone. The second compartment contains the secret contrivance which gives the operator control over the machine so that he can make it run at any required depth. A horizontal rudder is fitted to the stern or tail end. Whenever the torpedo is too high or too deep, the secret apparatus will act upon this rudder till the proper position is again resumed. The weapon, therefore, during its course does not describe a horizontal line, but oscillates continuously about its mean depth. Major Daudénart, of the Belgian service, and Mr. King, United States Navy, have given descriptions of what they believe to be the secret of this wonderful steering apparatus, but perhaps that given by Commander Sleeman is the correct one. He says: 'The adjustment chamber is connected by screws to the foremost and after chambers of the torpedo in such a manner that by means of a number of small holes bored round the circumference, the faces of the chamber are exposed to the pressure of the water, which varies with the depth to which the torpedo descends. Within the chamber is an endless strong spiral spring attached to the after face of the chamber, and so arranged that—after being set to a certain tension capable of resisting an equivalent pressure on the outside of the aforesaid face—any increase or decrease in this exterior pressure will cause the spiral spring to work a rod, by which the horizontal rudders of the torpedo are regulated, and thus the desired depth for which the spring is set is maintained. The course of the torpedo,' as it has been said, 'is represented by a series of curves above and below the line representing the depth it is set for; these curves gradually decrease until at 100 yards' distance from where the torpedo was started the curves are so small that the path of the torpedo is almost identical with a straight line. Within this adjustment chamber is also placed an automatic balance, which also assists to maintain the torpedo at the desired depth, by reason of its swinging forward on the torpedo descending and swinging aft on its rising, which motion is used to regulate the horizontal rudders. The above is merely a general idea of the arrangement in the Whitehead fish torpedo to enable it to reach and maintain whatever depth may be necessary to use it, at from five to 15 feet.' The torpedo has an apparatus within it which is capable of several adjustments. For example, it may be so adjusted

that the torpedo, at the end of its run, will ascend to the surface, where it can be recovered; this is important for experiments in time of peace. It can also be so arranged that, if it miss its mark, it will sink to the bottom at the end of the run and be harmless. Provision is also made for the recovery without danger of loaded torpedoes which have missed their object; they are allowed to rise to the surface, and as soon as the run is ended, the safety arrangement pushes itself over the igniting apparatus, so that the latter cannot act. The after compartment contains the reservoir, in which is carried the force supplying the necessary driving power to the engine. Compressed air is made use of as the power. The reservoir is pumped so full that the air exerts a pressure of 65 to 70 atmospheres. It is tested up to a pressure of 100.

Motive power. In the aftermost part there is also a small three-cylinder engine of the Brotherhood type, which is set in motion by the pressure of the compressed air, and turns the screws in the tail at a great speed. The whole pressure is not exerted on the pistons, as the rapidity of their movement would be too great, and the whole supply would be used up in a short time. A simple apparatus for regulating the supply has been introduced, and the exit of the compressed air is kept always at a pressure of from 18 to 40 atmospheres, according to the speed. This is consequently uniform up to the last minute, and the supply of air is sufficient for a longer run. The arrangement can be so fixed as to give a greater or less speed.

Steering and firing apparatus. Fish torpedoes can run an English mile at a speed of about eight knots. They have, in addition to the horizontal, an ordinary vertical rudder, which is fixed 'amidships' so as to correct any lateral deviation resulting from the motion of the screw. The screws are double, one before the other. The outside presents a smooth, polished surface with a small trigger on the upper part of the air-chamber, and a few screws recessed for the reception of keys. One of these at the side of the second compartment has an index attached marked in feet. The index being turned to the required number the torpedo will submerge itself and proceed at the depth indicated. The trigger is simply a lever for opening the air-valve. This is done by hand when the weapon is launched from a boat, or is drawn back by a catch when it is shot out of a tube from a ship. To guard against accidents there are two safety pins, which prevent the action of the fuse. One is removed at starting, but the other can be so arranged as to remain in its place until a certain number of revolutions of the screw have been made, by which the torpedo is carried to a safe distance from the vessel using it, so that it cannot explode too near her.

Latest improvements.

The following brief and general description, though repeating something of what has been already said concerning these weapons, will give an idea of the machine as provided with the latest improvements. The inside of the torpedo affords space for the reservoir for compressed air and a set of very ingenious machinery, each part of which has its special use. One part propels the torpedo at the depth desired; another regulates the direction and prevents deviation from it; a third causes explosion after a run of a certain distance; a fourth causes the same on contact with a hard opposing substance; a fifth stops the engines at the end of a specified run; a sixth makes the torpedo sink or come to the surface, as desired, when the engines stop. The torpedo is made to sink when it is sought to prevent its falling into the hands of the enemy against whom it has been fired unsuccessfully. In the employment of this torpedo certain special appliances for giving it the proper direction on starting have been devised. In some navies there is an above-water arrangement, or 'torpedo gun,' from which it is ejected by the pressure of air. There is also an under-water arrangement, consisting of a long tube, from which the weapon is ejected in a similar manner. There is a third apparatus, resembling a platform of gratings, from which the torpedo is not ejected, but merely lowered into the water, when its engines are set in motion. The 'launching tube' of the German service, resembling that of our own, is a long metal cylinder extending from the inside of the ship to the outside; it gives direction to the torpedo as a gun does to its projectile. For this purpose there are in the inside grooves in which projections on the torpedo-case fit. The tube is closed at the outer end by a watertight slide, and the torpedo is placed in it from above, to permit which there is a cover which can be made air and water-tight.

The sections of the torpedo are put together below, outside the torpedo-room, and it is run along through the several compartments of the ship on a small truck until it is beneath its proper hatchway. It is hoisted up through this, and is placed in a light iron framework carriage, in which it is run from the hatchway to the tube; here the carriage is placed so that the nose of the torpedo is pointing into the tube, and the tail is close to the charging column. The crew consists of six men, one at the magazine below and the remainder with the torpedo. When in place it is charged with compressed air by means of a small copper pipe, one end being screwed to the charging column, the other to a small hole in the left side of the torpedo. A pressure of 750 lbs. is sufficient for practice; 1,000 lbs. or 1,200 lbs. would be required were the weapon to be used in earnest. When

the gauge shows that the proper pressure has been reached the valves are closed and the charging pipe unscrewed. A toothed wheel is then set to the number of teeth ordered to regulate the length of the run, each tooth being equivalent to a distance of 40 yards. This wheel also pulls out a safety wedge when the torpedo has travelled 80 yards from the ship, so that there should be no danger of a premature explosion too near.[1] The depth having been allowed for, and the amount of pressure in atmospheres for the required speed, the firing apparatus is screwed in, the safety pin is withdrawn, and the torpedo is pushed into the tube. The 'impulse tube' is then put on, and the torpedo is ready for firing. The impulse tube, which resembles a telescope in form, is forced out by compressed air, and, pushing the tail of the weapon, gives it a good start on its journey, the compressed air afterwards forcing the telescopic slide in again. As the torpedo is pushed out, a small projection on the upper part of the tube inside catches a small lever on the top of the torpedo itself and throws it back. This action opens the air-valve, and admits air from the reservoir to the engines, and so sets the screws going.

There is no reason to believe that we have yet reached the limit of development of which the powers of this weapon are capable. Recently Mr. Whitehead has submitted for experimental trial a platform for launching his torpedo from the side of a ship in motion.

Gradual development of the invention.

It has arrived at its present state of efficiency slowly and by degrees. As before stated, it was invented, in the first place, by Commander Lupis, of the Austrian Navy, who spent six years in the preliminary researches at the expense of his Government. He made substantial progress, but the steering and propelling apparatus still left something to be desired. Partly availing himself of the scheme proposed by Lupis, Mr. Whitehead, who was then residing at Fiume, produced another and more perfect contrivance. After long years of practical trials and patient labour he laid his plan before the Austrian Naval Administration. The improved machine was in this way first introduced into the Austrian Navy, from which, since the year 1873, it has been extended to other navies. The careful and diligent inventor at length succeeded, in 1874, after indefatigable exertions, in rendering his torpedo the most remarkable among the instruments of destruction which the wonderful invention of the present day has produced. This ingeniously contrived machine must be admitted to be the most terrible and powerful weapon of modern naval warfare.

[1] It has occurred that a torpedo, launched for practice from an English ship of war, turned round and ran back to the ship. The same has been stated of one used by the Peruvians in the present war.

The charge is sufficient to make an opening of 44 square feet in the double bottom of the strongest ironclad, and the explosion will take place on the slightest impact.

Extent of manufacture.

The number of these torpedoes manufactured of late is very large, and they have been chiefly turned out at Mr. Whitehead's works at Fiume, though a certain number are made for the English Navy at the Royal Arsenal at Woolwich. In the Fiume factory 300 men are employed, and there are engines supplying motive power for seventy machines. Torpedoes are made there for England, Germany, Russia, and Portugal as well as for Austria.

Though adopted early by some maritime Powers, the belief that the Whitehead torpedo could only be employed with effect in specially constructed vessels at first restricted its use. Since it has been found practicable to launch it from ordinary ships of war, its adoption has become general. The following is a statement of the numbers of torpedoes supplied from Fiume to foreign Governments:—

Germany	200
France	200
Denmark	50
Sweden and Norway	50
Portugal	50
Russia	100
Great Britain (besides home-made ones)	200

Italy has procured a few, and is constructing 200 at home.

The earliest recorded experiments with the Whitehead torpedo were carried out by a committee composed of officers of the Austrian Navy and Artillery in the years 1867 and 1868. The first trial served to determine the charge. Two torpedoes were constructed with the following dimensions, charges, and weights:—

	First Torpedo.	Second Torpedo.
Charge	40 lbs. gun-cotton	60. lbs. gun-cotton
Length	12 feet	14 ft. 6 in.
Diameter	14½ inches	16½ inches
Total weight	280 lbs.	490 lbs.

The pressure for launching was 473 lbs. The directing tubes were of the same length as the torpedoes, and their diameters were respectively 17⅓ inches and 23¼ inches. To carry the torpedoes a gunboat called the 'Chamois' was fitted, the directing tube being fixed to her at the proper depth. When launching a torpedo the vessel was stopped or the helm put hard over. The target was a net 206 feet long and 23 feet deep stretched between two boats. The report stated that the number of hits was 50 per cent. of the shots. When the gunboat was in motion the practice was not so good. On receiving

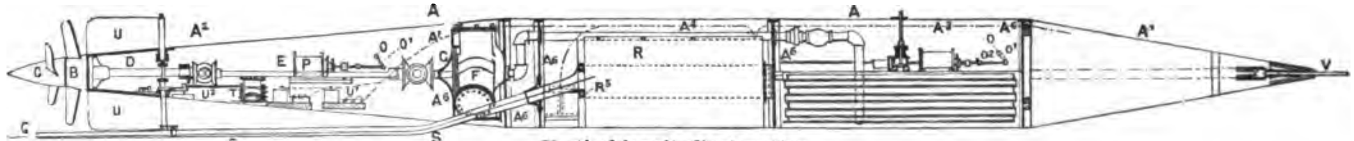
a favourable report from the committee the Austrian Government purchased the secret from the inventor, leaving to him the right to sell it to other Governments.

The Lay torpedo.

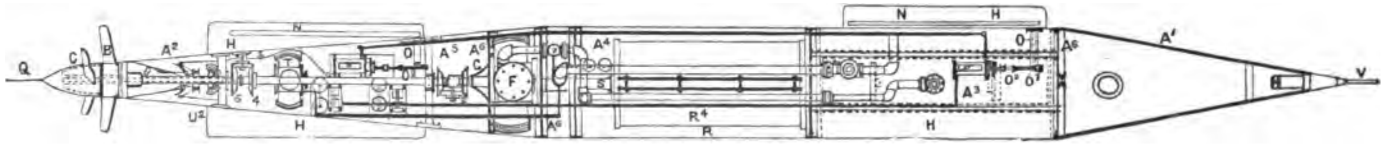
Another automatic or self-propelling torpedo has been designated, after its inventor, the Lay torpedo. The case is somewhat spindle-shaped, 28 ft. 3 in. long, and made of iron or steel plate. It is divided into four compartments. The foremost section contains the charge of explosive material, which is 300 lbs. of powder or 75 lbs. of dynamite. The next in order contains the motive power, which consists of ammoniacal gas generated by pouring ammonia from flasks, in which it is carried, on a carbonate. The gas has an initial pressure of forty atmospheres, and is conducted from the generating apparatus through iron tubes to the engine, which is fitted up in the fourth compartment. The third section contains a roll of ten miles of insulated wire, which is paid out from the reel itself, and serves to keep up electrical connection with the firing station. The torpedo is under the control of the electrician, who, by means of a series of contacts, opens or closes certain valves, and thus increases or diminishes the speed, and stops or steers the torpedo as circumstances may require. The weapon is submerged to about four-fifths of its volume, and cleaves its way through the water at an average rate of 10½ knots an hour.[1] Its position is always known by slender guide poles which project from it above the surface of the water. In the after end is the engine, working two screws one before the other, as in the Whitehead, turning in opposite directions. In some experiments made at Newport, the United States Naval Torpedo School, it is said to have run about a mile and a half. Von Ehrenkrook says that its 'weight is 40 cwt., whilst its speed is only from six to eight knots.' Sleeman, however, states that 'its weight is about one ton, its length is 23 feet, and speed twelve knots per hour.' As Mr. Lay a few months since brought some of his machines to Europe for trial, it is probable that he has improved on earlier models. One is reputed to have been tried at the Torpedo School at Newport in September 1879. It started off at the rate of about six miles an hour, and in turning, after going about three hundred yards, it began to slow down, and, before it was brought round, it came to a standstill. It is declared that this torpedo is exceedingly complicated, and consequently liable to get out of order. The cost is said to be from 4,000*l*. to 5,000*l*.

[1] On October 21, 1879, at Antwerp, some experiments were made with a Lay torpedo 23 feet long. The speed of this torpedo was 9 miles an hour. Some in course of construction for the Russian Government are said to have a minimum speed of 14 knots an hour.

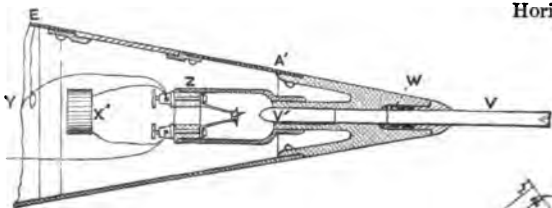
Figs. 85 to 89.



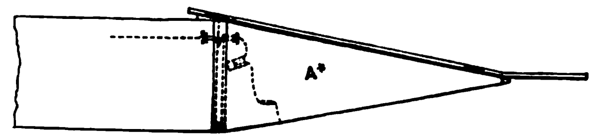
Vertical longitudinal section.



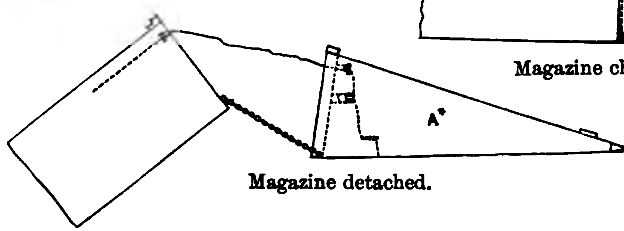
Horizontal longitudinal section.



Firing gear.



Magazine charge.



Magazine detached.

A^1, Magazine for charge; A^2, Steering gear; A^3, Gas reservoir; A^4, Cable compartment; A^5, Propelling engines; A^6, Watertight bulkheads; A^*, Explosive charge; B, C, Screws; D, E, Shafts; F, Machinery; H, Horizontal rudder; N, Guide poles visible above water; Q, Cable; R, Reel frame; S, Cable tube; V, Projecting pin; W, Charge chamber; X, Circuit closer; Y, Cartridge, or charge; Z, Connexions.

THE LAY TORPEDO.

The leading feature of the Ericsson torpedo is the supply of motive power by means of a steam-engine working an air-pump on the shore or in the vessel from which the torpedo is dispatched through a hollow cable connected with it. The reel on which the cable is coiled is placed on the torpedo itself. This machine is remarkable for both cheapness and simplicity of construction. The torpedo consists of a solid block of pine wood, shaped so as to pass through the water with the least resistance. A light vessel is inserted at the head to hold the explosive charge. A cavity cut in the block near the stern, contains the motive engine and steering gear, the reel revolving in a vertical perforation near the centre. The specific gravity of the wood being only half that of the water, the buoyancy of the solid hull of the torpedo will readily sustain the weight of the light motive engine and steering gear. The reel and cable are of the same specific gravity as the sea, and sustain themselves. The sea-water enters freely into the cavity which contains the motive engines, lubricates the crank-axles and other moving parts of the mechanism, and thus allows stuffing-boxes to be dispensed with. Steering is effected by admitting more or less air into the hollow cable. By turning on full pressure, a small piston connected with the tiller of the torpedo rudder is raised, and the helm brought to starboard. By partially checking the influx of air into the cable, the piston is allowed to descend, and the helm is turned to port. The position of the torpedo is indicated by a small circular disc attached to the top of a vertical steel wire fixed to the hull. This disc is intended to remain about two feet above the surface of the water. Thus the course of the torpedo can be watched by the observer, and may be altered at will. The driving propeller consists of two screws revolving in opposite directions. This contrivance was adopted in order to neutralise the effect of the water, or back-lash, on the rudder. The immersion varies from six to fifteen feet, and is attained by setting the 'driving pins' at an appropriate angle. The charge consists in some classes of 200 lbs. of powder or other explosive; it is lodged in the nose and is fired mechanically on impact. Owing to the length and weight of the hollow cable it has not been found practicable to send this torpedo to a distance exceeding a few hundred yards. Indeed, a range of only 150 feet has been given in some accounts as the limit of its power of running. If it miss the object, the air can be shut off and the torpedo hauled back by the hollow cable.

The Ericsson torpedo.

More than one other automatic torpedo has been proposed or even actually tried by other inventors. The torpedo invented by Captain MacEvoy retains some features of the outrigger system. It has

Other automatic torpedoes.

sufficient locomotive power to carry it about 100 yards. Behind the torpedo itself is a reservoir containing a carbonate and a bottle of acid which can be broken at will by a hammer worked by a line led to the boat. The fluid thus compressed is utilised to impart motion to the weapon. This is carried at the end of a spar, until near enough to be launched at the object attacked. The motive power of the torpedo invented by Commander Howell, U.S.N., is derived from the inertia of two heavy iron wheels, which are revolved before the torpedo is dropped at the great speed of from 4,000 to 10,000 turns a minute. It has an automatic steering and driving apparatus, and has been tried successfully at short distances.

The Harvey,' or towing torpedo.

The principle of Captain Harvey's torpedo is derived from a wooden float, called an 'otter,' a contrivance extensively patronised by poachers in Scotland for the purpose of conveying their lines out into mid-stream, thereby enabling them to dispense with the use of long fishing-rods. It is towed at the end of a long line connected to a spar, so arranged that the torpedo itself, instead of following immediately in the wake or trail of the vessel towing it, diverges in the same manner as the otter float, from which the idea is borrowed. Attached to the torpedo are two large buoys for the purpose of supporting it when the vessel is not moving through the water, or when the towing line is slackened. Thus, on meeting a friendly ship, or if not wishing to explode it, the line is at once let go, and the torpedo sinks below the vessel instead of touching her side or bottom. On the line being tightened again the torpedo at once diverges. It must be understood that there are two kinds of torpedoes served out to each vessel, though they differ only as regards the position of their respective planes, so that they may diverge, the one to port, the other to starboard. Each torpedo consists of an external case of well-seasoned wood about 1½ inch thick, screwed together with watertight packing between the joints and bound with iron, the interior being usually cemented with pitch. The inner case is constructed of stout sheet copper, carefully soldered at the joints, and provided with a cylindrical tube running through the centre, into which is fitted the exploding bolt and priming charge; it has also two circular ports about 3½ inches in diameter, one on either side of the bolt, for charging the torpedo. These ports are made watertight. The priming case is made of stout sheet copper, and contains a large bursting charge of fine-grained powder or gun-cotton discs.

In the centre of the priming chamber or cylinder is a brass tube in which the exploding bolt works; and at the bottom of this tube is a steel-pointed anvil which, when the bolt is forced down, pierces the

capsule, and, striking the muzzle, ignites the detonating compound, and, through the bursting charge, the main charge itself. The torpedoes, in order to facilitate their use in every way possible, are made in two sizes, the dimensions of the external case being as follows :—

Large Torpedo.

Length	5 feet
Breadth	$6\frac{1}{8}$ inches
Depth	1 ft. $8\frac{3}{4}$ in.

Small Torpedo.

Length	3 ft. 8 in.
Breadth	5 inches
Depth	1 ft. 6 in.

The following is a selection from the scale of charges of different explosive compounds that the internal cases are capable of containing. The materials must be carefully packed, and the calculation depends on the larger case being of sufficient capacity to contain 77 lbs. of water and the smaller one 28 lbs. :—

	Large	Small
Compressed gun-cotton . .	60 lbs.	22 lbs.
Rifle fine-grained powder . .	76 „	27 „
Blasting powder . . .	85 „	30 „

With a view to prevent accidental explosion, the bolt is made to work with a pressure of 40 lbs. in the large torpedo and from 15 to 20 lbs. in the smaller one. As a further precaution, and in order to prevent the accidental bursting of a torpedo on contact with a friendly ship, a safety key is employed, passing horizontally through the spindle and resting on the brass muzzle of the priming case. A small strong line, known as the safety key-line, serves to remove the safety key on the approach of a torpedo to an enemy's ship. The torpedo when towed into contact with the object attacked is exploded by levers, which are arranged to press on the exploding bolt. The levers are so fitted that either a top or side blow forces down the exploding bolt, which being connected with the after top-lever—connected in its turn with the fore top-lever—may be driven home by one of them. An important modification of this torpedo permits of the use of electricity, the insulated wire passing through the core of a wire rope to the instrument itself. Difficulties, which have been foreseen in the way of manœuvring the weapon in action, have led to its abandonment in the British service.

In the French navy a towing torpedo is supplied to all ships, which is manœuvred in a manner similar to the Harvey, but is of very different form. It is a long cylinder with a chisel edge at one end, the

The French towing torpedo.

sides being so inclined as to secure the proper amount of divergence. It is without buoys, and is towed by a line led from a point as far forward in the ship as possible. To secure success with a torpedo of the Harvey class it must be carefully watched; and the risk to the ship which uses it in a naval engagement is too great and the chance of success too small to make it perfectly safe to employ it as an offensive weapon. Torpedoes of the kind are like the outworks of a fortress to the enemy who chooses to throw himself against them, but nothing more.

Ericsson's *aggressive* gun torpedo.

Captain Ericsson has very recently made some experiments with a torpedo of cigar shape expelled from a smooth-bore gun of large calibre by the explosion of a small charge of powder. It is probable that further trials of this ingenious device will be made. At present the information that can be obtained concerning it is too meagre to permit of any conclusion being formed as to its value.

Section III.—*Special Torpedo Vessels and Torpedo Boats.*[1]

The important part which torpedoes and torpedo-boats have already played in war, and the efficiency which they are likely to exhibit in future campaigns, have been pointed out in the previous sections of this chapter. It seems to have been thought for a long time that, when required, both torpedoes and the means of using them could be readily extemporised, or could certainly be obtained so quickly that it was unnecessary to make provision for them till we were actually at war. Something was done in this direction by our own Government and others in the establishment of arrangements for torpedo practice, both for training and experiment. Recent developments in the construction of small vessels, and conclusions arrived at in regard to the torpedoes themselves, have shown that although much might be done with hastily-prepared torpedo boats, every war navy must now contain some vessels specially designed to use the new weapon.

Special torpedo-vessels.

The special craft constructed for the purpose of employing torpedoes as their chief weapon range from torpedo-vessels, such as the 'Polyphemus,' the 'Vesuvius,' and 'Ziethen,' to the swift torpedo-boats, of which large numbers have of late been designed for our own and foreign Governments. The 'Polyphemus' has been described in a former part of this work. (See Vol. I. pp. 472–6.)

Vessels specially built for torpedo service may conveniently be divided into three classes :—

[1] Much of the information contained in this section has been derived from an interesting article on 'Torpedo-vessels' in the *Nautical Magazine* for December, 1880.

1. Seagoing torpedo vessels.
2. Harbour and coast-defence torpedo-vessels, known as 'first class torpedo-boats.'
3. Boats which can be carried on ships' decks, known as 'second-class torpedo-boats.'

The first vessel in the English Navy, designed specially for torpedo service, was the 'Vesuvius,' built about 1875. She had a displacement tonnage of 260, but has a speed of nine knots only, which falls much below what is now considered necessary in all vessels designed for this service. The 'Vesuvius.'

The 'Vesuvius' is fitted to discharge fish torpedoes under water, and carries ten of them. She was intended to be smokeless and noiseless, coke being used as fuel, and there being no blast or escaping steam on deck. The proportion of beam to length is considerable, being no less than 22 feet with a length of 90 feet. To secure facility in manœuvring, she is fitted with twin screws. There is no funnel in the ordinary sense of the term, the products of combustion from the furnaces being carried along and close to the upper deck, to a point just abaft the engine-room, where they escape across the deck through openings in the side of the flue. To maintain the necessary draught through the furnaces, a fan is fitted in the common uptake driven by a three-cylinder engine coupled direct to the fan spindle. The accommodation for officers and crew is limited, and indeed the complement is reduced to the smallest number consistent with the work to be done. The vessel is built entirely of iron; but to prevent slipperiness on the iron deck when wet, it is coated with cork cement. For the purpose of raising steam, during which it is of course impossible to work the draught engine, a temporary vertical funnel has been fitted just over the fan. When the steam is up, this funnel can be removed, folded down to rest on the funnel proper, and when necessary, taken to pieces and stowed away on the deck itself. The vessel is directed from a conning tower near the bow, of which only the upper part is raised above the deck. The sides are pierced with slits through which the helmsman can direct his course.

The 'Ziethen,' built for the German Government in London, is an unarmoured iron-built ship, 226 feet long, 28 feet broad, and 18 ft. 6 in. deep. The burthen is 872 tons B.M., and the load draught 11 ft. 8 in. She is propelled by twin screws, driven by a pair of Penn's engines of 2,500 indicated horse-power, which should give a speed of 16 knots. The 'Ziethen' is fitted with two tubes placed in line with her keel, one forward and the other aft. They are six feet below the water-line, and from them the torpedo is to be expelled by The 'Ziethen.'

means of compressed air. It is intended that the torpedo, when required for use, should be expelled from the tube at a speed of twenty knots an hour, and after expulsion a speed of twelve knots is to be maintained by means of the self-contained propelling power in the torpedo itself. It is expected that this speed will be kept up for a distance of 600 yards under water, as is the case with Whitehead torpedoes of the class employed.

The 'Uhlan.'

Another vessel designated an 'offensive torpedo steamer' has been constructed for the same Government at Stettin, in Germany. According to published accounts this vessel, which is to be called the 'Uhlan,' will be armed with a torpedo charged with dynamite, to be carried on the extremity of a ram, deep under water, and protruding to a distance of ten feet. The torpedo is to explode on contact. To prevent injury from the results of an explosion, the vessel is built with two complete fore parts, fitting one within the other. The intermediate space, which is considerable, is filled with a tough and elastic material, consisting of a compound of particles of cork and marine glue. It is anticipated that, if the false stem were carried away, there would be a second line of resistance, the filling serving the purpose of a buffer, to deaden the blow and protect the stem. The engines, which indicate 1,000 horse, are exceptionally powerful. The internal capacity of the vessel is mainly occupied with the machinery, only a very small space being reserved for coal and the accommodation of the crew. The length is said to be 70 feet. and beam 25 feet. In order to save the crew, in the not improbable event of the destruction of the 'Uhlan,' a raft has been made which is filled with the same mixture of cork and marine glue which has already been described. The raft is placed near the helm. When the 'Uhlan' goes into action, the dynamite torpedo is to be fixed at the point of the ram; the rudder is then to be lashed, and the crew are to open a wide port in the ship's side, and, with their raft, jump into the water. The steamer is then allowed to rush forward and explode her mine against the enemy. The raft, however, on which the crew have taken refuge is to remain in tow by a line, whilst awaiting the result of the explosion, and in case their craft is not hurt, the crew are to board her again, in order, if necessary, to repeat the manœuvre. It remains to be seen whether the above description conveys a faithful picture of this remarkable craft and the proper method of handling her, or whether it is merely an account of his device given by some sanguine inventor.

The 'Pietro Micca.'

For the Italian Government a vessel has been built called the 'Pietro Micca.' The dimensions are: length between perpendiculars,

202 ft. 11 in.; breadth, extreme, 19 ft. 8 in.; draught of water, 11 ft. 10 in.; displacement, 535 tons. The vessel's bottom amidships is perfectly flat and meets the sides, which are vertical, by curves which form arcs of a circle. The vertical sides from the lower part of the hull and the upper works are joined by very sharp curves. The principal object in the construction of the ship has been to ensure great speed, to chase and attack an enemy, and retire to a distance after delivering a blow. Nearly the entire internal capacity of the hull, which is extremely long and narrow, is occupied by the propelling and evaporating machinery and the small supply of coal. The fore compartment occupies about a fourth of the internal length of the ship, and contains the mechanism for launching the torpedoes. The berths for the crew, provisions, water, and spare stores are placed on the lower deck, on which also is stowed a portion of the coal. The engine is to develop an effective power of 1,400 horses. There are four boilers and two funnels. The four boilers are divided into pairs, and each pair is in a separate compartment. The vessel is built of iron. The sides are unprotected, but the lower deck, placed about ten inches below the water-line, is armour-plated. This deck is horizontal for a space of seven feet in the centre, whence it slopes down gradually towards the sides of the ship. The armour of the central horizontal part is composed of three sheets: one of steel, six inches, and two of iron, each eight inches in thickness, making up a total of 22 inches of plating. At the side the thickness of the plates is reduced from eight inches to four. The vessel is armed with ten Whitehead torpedoes and two machine guns. The extreme speed is calculated at 18 knots.

The 'Ran.'

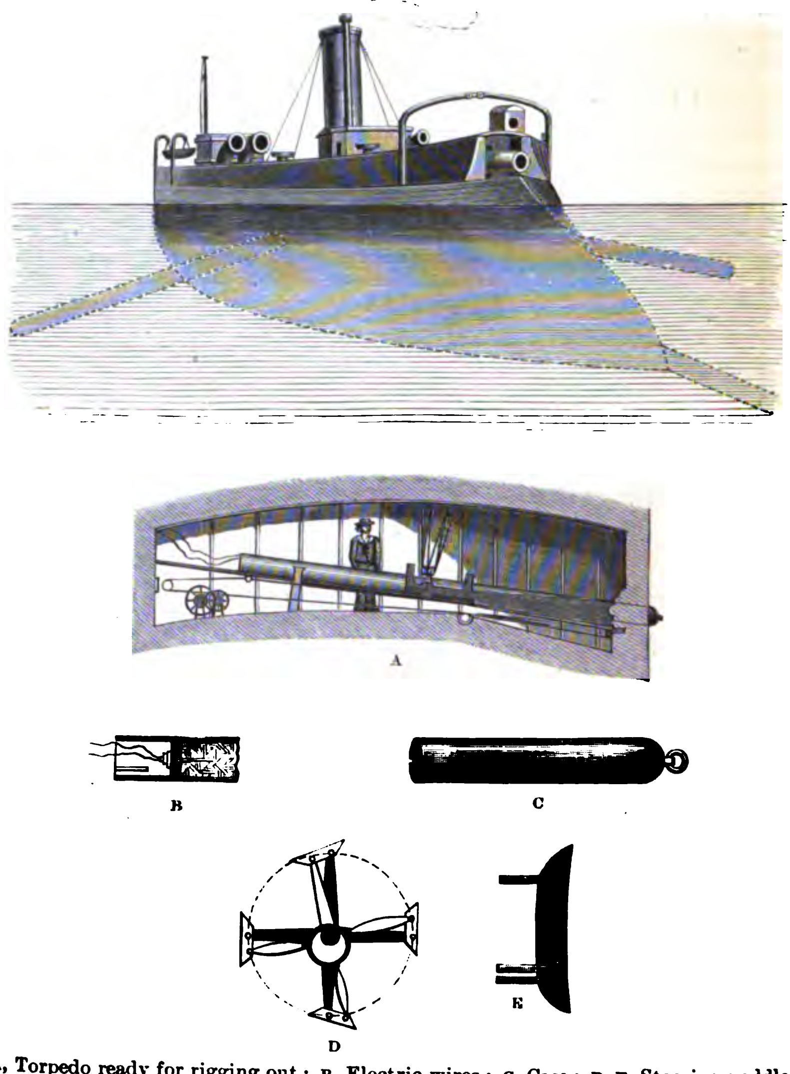
The Swedish torpedo vessel 'Ran,' built in 1877, at Stockholm, is a somewhat larger vessel, her displacement tonnage being 638. She has a speed of only 12·8 knots. The 'Ran' is intended to make use of the Harvey towing torpedo, and is also fitted with arrangements for using the Whitehead fish torpedo, of which eight are to be carried on board, but twelve could be carried if desired.

The 'Alarm.'

In the United States a torpedo-vessel called the 'Alarm' has been completed at the Brooklyn Navy Yard from designs by Admiral Porter, of the United States Navy. This vessel is built of thoroughly tested charcoal iron, on the English bracket-plate system. The hull is doubled, one shell being constructed inside the other. Within the outside shell three longitudinals of great strength are carried along the entire length of the vessel, and connected by brackets with cross-bars laid horizontally. The compartments formed are thus water-

tight, and the whole interior of the vessel is minutely subdivided. As it is proposed that the vessel should be almost wholly submerged whilst in action, the plating on the sides is thin, and armour-protection

Figs. 90 to 95.



A, Torpedo ready for rigging out; B, Electric wires; C, Case; D, E, Steering paddle.

THE 'ALARM.'

is given up; the length is 172 feet, of which 32 feet are taken up by the ram. The beam is 27 ft. 6 in.; the draught of water is eleven feet, and the displacement about 700 tons. Great readi-

ness in turning is secured by the total abolition of the rudder and by steering with the propeller, which consists of a feathering paddle-wheel turned horizontally instead of vertically. By suitably turning the cam wheel, which is done from the helm, the paddles may be feathered in different positions, and in this way the ship may be turned, or rather, her stern twisted round as if on a pivot. At the same time, by suitably adjusting the paddles, the vessel goes ahead or astern, the engines meanwhile running always in the same direction. A smooth-bore 15-inch gun is mounted in the bows on an ordinary naval carriage. It is worked by its tackles being taken to a steam capstan. When run out the gun points right ahead. Three outriggers or torpedo-spars are carried, one at the bow and one on each side. The bow outrigger is a long hollow iron cylinder, lying, when not in use, on its supports between decks. The outboard end rests in a kind of trough, and to this extremity the torpedo, a metal shell containing a heavy charge, is fastened. For the electric fuse platinum wire is used. To the cradle, in which the torpedo outrigger lies, are attached tackles hooked to the beams overhead in such a manner that the spar can be tilted to different angles, and that its extremity, when pushed out, may be at a greater or less depth under water. The valve through which the spar passes is so constructed that no water can enter, the side spars are eighteen feet, and the bow spars 32 feet in length. If the vessel to be attacked should be defended by torpedo guards or obstructions, an ingenious mechanical contrivance on the torpedo gives warning to the person stationed at the battery not to press the firing key. The vessel has a steel-plated deck, has storage room in the bunkers for five days' supply of coal, and when necessary can carry on deck sufficient coal for three days more. Accommodation is provided for six officers and sixty men, and two months' provisions. The 'Alarm' is a good torpedo-vessel, but deficient in speed. She will, in her designer's opinion, be effective for harbour defence until improved machinery is provided to drive her at least fourteen or fifteen knots. It was believed that the 'Alarm' would attain a speed of twelve knots, but when she was tried at the measured mile in January 1880 she did not go faster than ten knots.

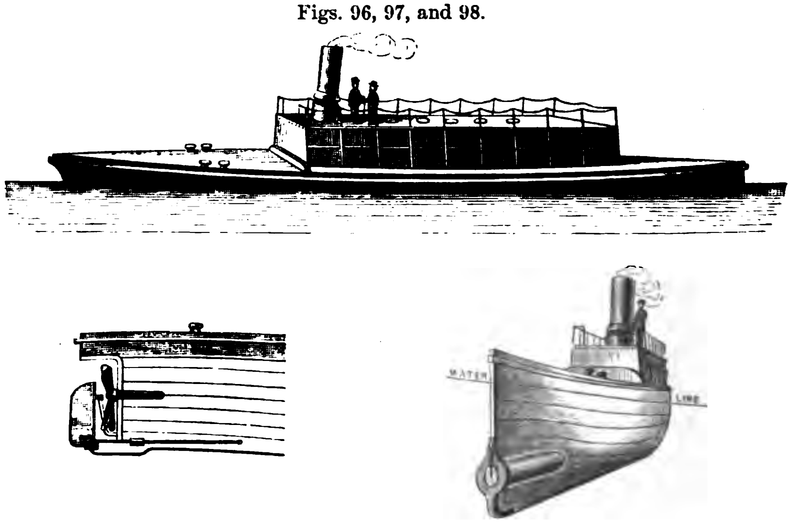
The Americans have also had some time in hand a vessel designed for torpedo service exclusively, named the 'Intrepid,' of 1,123 tons displacement, which was launched in 1873. The principal dimensions are:—length, 170 feet; beam, 35 feet; draught, 12 feet. The speed does not exceed nine knots. The 'Intrepid.'

The *Nautical Magazine* gives the following account of an early

The 'Spuyten Dyvil.'

specimen of the modern special torpedo-vessel. The 'Spuyten Dyvil,' as she is called, was begun by the United States Government during the Civil War, but was not completed in time to be of any use in that contest. The dimensions were 74 feet long, 20 feet beam; she had 7½ feet draught of water, but, on going into action, she could be immersed to a depth of nine feet, in order to put her unarmoured side below water. It was intended that when engaged the deck only should be about the surface of the water, and this deck was plated with 3-inch armour. Amidships, and standing about three feet above the deck, was a pilot-house, from which the vessel was to be steered, &c. The torpedoes were to be worked through a hollow iron boom projecting from the bow, and having inside it a rod to which the torpedo was to be attached. The torpedo was to be fired by contact, when a detonating cap was struck. The 'Spuyten Dyvil' was said to have engines that were noiseless. We believe that they were of very low power compared with similar vessels in the present day. She was built of wood, and if in existence at the present time it is most probable that her timber, especially that in contact with the iron armour, is so far decayed that she would be useless.

Figs. 96, 97, and 98.



Screw and rudder. Bow, with torpedo-tube.

THE 'DESTROYER.'

The 'Destroyer.'

In August 1878 Captain Ericsson's torpedo-vessel the 'Destroyer' was launched on the River Hudson. The form of the hull is peculiar, both ends being precisely alike, terminating with fine wedges, probably sharper than any vessel of deep draught yet built. The length

is 130 feet, depth eleven feet, extreme beam twelve feet, thus preserving the proportion of eleven times greater length than breadth. The rudder requires special attention, as it is wholly unconnected with the vessel, part of the stern being attached to a vertical wrought-iron post welded to a prolongation of the keel just abaft the propeller, its upper part being nearly four feet below the water-line. The tillers consist of thin plates of iron, riveted on opposite sides of the rudder a few inches from its bottom. These tillers are worked by straight rods, connected to the pistons of horizontal hydraulic cylinders of five inches diameter attached to the sides of the keel. The steering gear is thus placed ten feet below the water-line, while the top of the rudder only reaches within four feet of it. The leading feature of the construction of the hull is its being provided with an intermediate curved deck, extending from stem to stern, composed of plate iron strongly ribbed and perfectly watertight. This intermediate deck sustains a heavy solid armour plate, placed athwartships, 32 feet from the bow, inclined at an angle of 45°, and supported on the after side by wood backing 4 ft. 6 in. deep at the base. The steering wheel is established behind this wood backing, a wire rope extending from its barrel to a four-way cock near the stern, by which water pressure is admitted alternately to the hydraulic cylinder, the motion of whose pistons actuates the rudder. During an attack the 'Destroyer' is intended to be deeply immersed in the water, a deckhouse or cabin seventy feet long being riveted watertight to the upper part of the hull.

Torpedo-launchs.

Ordinary ship's boats, even when propelled by steam, having proved unequal to the work of employing the spar or outrigger torpedo efficiently, a special class of boats of great speed has recently been designed, and large numbers of them have already been added to the British and other navies. These boats hold an intermediate position between the steam launches or steam pinnaces of ships of war, temporarily fitted to manœuvre torpedoes, and the regular torpedo-vessels just described. The object of these boats is, by the attainment of a speed of fifteen or more knots an hour, to attack any ship of war, by coming up with her, launching a torpedo against her, and then retreating.

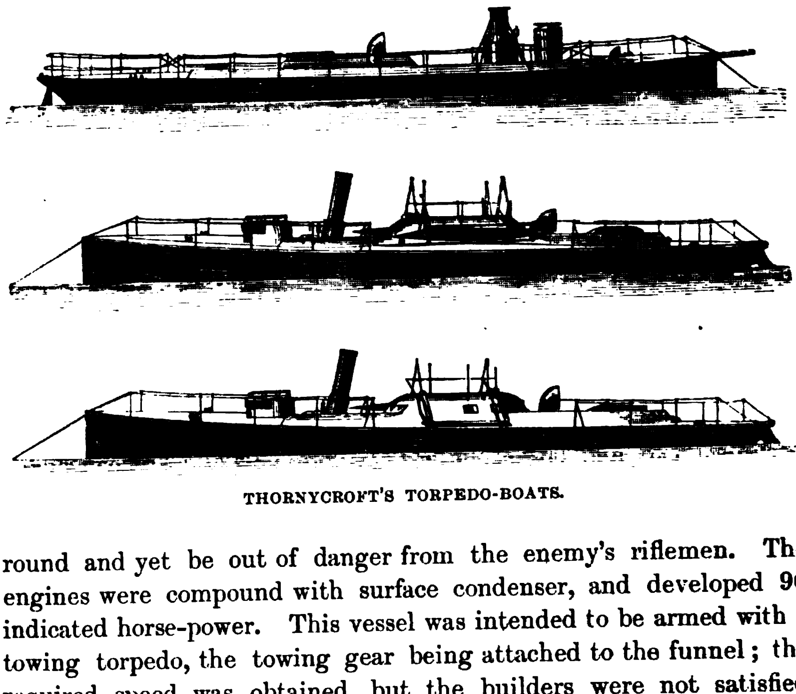
Thornycroft torpedo-boats.

Messrs. Thornycroft,[1] of Chiswick, in 1871, demonstrated the feasibility of obtaining high speed out of very small vessels, and the history of the early designing of small craft specially adapted for torpedo warfare is contained in a paper read before the Royal United Service Institution, by Mr. John Donaldson of that firm,

[1] The following account of the different kinds of torpedo-boats is chiefly taken from the *Nautical Magazine* for December, 1880.

in May, 1877. The first high-speed boat was built by them for the Norwegian Government in 1873. She was 57 feet in length, $7\frac{1}{2}$ feet beam, drew three feet of water, and was to have a speed of 16 miles, or nearly 14 knots; she was constructed entirely of steel, and was divided into six compartments by watertight bulkheads. Of these the extreme end compartments are occupied by stores, the two next to them are fitted with seats for the crew, and have moveable steel covers to enclose them in bad weather or on going into action. (Figs. 99, 100, 101.) The two midship compartments are covered completely by steel plating $\frac{3}{16}$ inch thick, to keep out musketry bullets; one is for the steering gear, the other for the machinery. There is a hood with slits in it, to enable the steersman to see all

Figs. 99, 100, and 101.



THORNYCROFT'S TORPEDO-BOATS.

round and yet be out of danger from the enemy's riflemen. The engines were compound with surface condenser, and developed 90 indicated horse-power. This vessel was intended to be armed with a towing torpedo, the towing gear being attached to the funnel; the required speed was obtained, but the builders were not satisfied with the performance of the propeller, and Mr. Thornycroft invented one which is a modification of what is known as the Dundonald propeller. In the last-named the blades are inclined backwards, but are straight. In Mr. Thornycroft's they are curved, the curve being of such a character that the blade has a greater inclination to the axis at the boss than near the tip; the speed then obtained was 15 knots per hour. This boat was followed by two others for the

Swedish and Danish Governments respectively. Further improvements were made in the machinery, the result being in the case of the Swedish boat a speed of 15¾ knots per hour. The Danish boat was armed with towing torpedoes, and it is worthy of remark that when actually engaged in towing one of them her speed was reduced to ten knots. This fact must tell very much against the efficiency of any towing torpedo except it be towed by a much larger vessel. These boats were of course of very light construction, and some misapprehension was expressed as to their strength, but it is stated that the Norwegian boat was, through some mistake, out in the open sea of the Baltic in rough weather, and not only behaved well but showed no signs of weakness.

Boats for foreign Governments.

The next boats built by Messrs. Thornycroft were two for the French, and one for the Austrian Governments. Their dimensions were: length, 67 feet; beam 8½ feet; draught, 4¼ feet; indicated horse-power, 200. The plates in these boats were slightly thicker, and the spaces occupied by the crew were permanently covered in. The armament consisted of two torpedoes on wooden poles about 43 feet long, fired by electricity, either on contact with the enemy or at the will of the operator. The poles were run out through tubes attached to the deck of the boat, and so arranged that the poles might be placed either over the bow or from the broadside. These boats made over 18 knots per hour, and the French boats were considered so far fit for service in rough water, that they steamed from the Thames and crossed the Channel in a direct line from Dover to Cherbourg. The French authorities, after trial of the boat, made an alteration of the spar arrangements, deeming it advisable to fight her end-on only, as then she was less liable to damage herself by the shock of the explosion. They fitted each boat with a steel pole 40 feet long. When run out the fore end is depressed to about 8½ feet below water. The experiments at Cherbourg were made by the help of these boats, and upon the 'Bayonnaise,' an old wooden frigate. The value of the experiments was not in proving, what everybody knew before, that a large torpedo explosion would make a big hole in a wooden ship, but rather as showing the effect of the explosion upon the boat herself. The boat, it is said, was completely covered by the water of the large wave raised by the torpedo, but was not in any way damaged, and steamed away from the scene of the experiment. The second boat ran into the ship by misadventure, and her bow was doubled up, but no damage resulted beyond the filling of the empty space in the fore-compartment. A third size of boat was built for the Dutch and Italian Governments;

these are 76 feet long and 10 feet beam, and have a speed of 18 knots. They have more freeboard to enable them to be out in rougher weather, and their horse-power is 250 indicated. The Dutch boats had spar torpedoes; the Italians were designed to carry the Whitehead fish torpedo.

The 'Lightning.' The first torpedo-boat built for our own Government was the 'Lightning,' in 1877. Her dimensions are: length, 84 feet; breadth, 10¾ feet; draught, 1½ feet forward and 5 feet aft, the latter including turn-down keel which encloses the propellers. Her speed is 10 knots; indicated horse-power, 350. The 'Lightning' has superior seagoing qualities to any of the former boats; she has thicker plating, and superior cabin accommodation. She was designed to use the Whitehead torpedo, discharged through a tube above the water. A new system of propulsion, the invention of Mr. Thornycroft, has been applied to this vessel. The 'Lightning' in 1876, fitted with an ordinary screw abaft the rudder, attained upon her official trial, which took place in Stokes Bay, a speed of 18·54 knots per hour. The steering, however, on this occasion was not particularly good, the times of turning the circle being 3 minutes 50 seconds to starboard and about the same time to port. With a view therefore to improve the steering power, and, if possible, also the speed of the vessel, the Admiralty commissioned Messrs. Thornycroft and Co. to fit her up with an apparatus which consists of a propeller of small diameter encased in a cylinder, which carries at its after-end fixed guide-blades arranged in such a way as to throw the water from the propeller directly aft. Thus far it is similar to the propelling arrangement of Mr. Rigg and Mr. Parsons. It differs, however, considerably from the propelling arrangements hitherto adopted in having the boss of the propeller prolonged in the form of a cone through the fixed guide-blades to a considerable distance astern of the enveloping cylinder—the object being, by narrowing the area, to increase the velocity of the stream coming from the propeller while passing through the apparatus. In the case of the 'Lightning' this cone is made in three parts—one consisting of the propeller boss, the second of the boss in the centre of the guide blades, and the third attached to the rudder. On each side of the enveloping cylinder are fixed wing-pieces, so arranged that when the rudder is put hard over, the wing-piece on the opposite side closes the aperture leading from the screw on that side and turns the water entirely through the aperture on the opposite side. The vessel was made to circle in the river, and it was found that the circle to port was made in 1 min. 15 sec., and to starboard in 1 min. 5 sec.; a result which is a great

improvement on the speed of turning on the occasion of the official trial. The stem of the boat was then secured to the pier and the stern propelled sideways, so as to make the vessel turn a complete semicircle against wind and tide round the stem as a centre. Among the other improvements effected in the 'Lightning' by the introduction of the new propelling arrangement may be mentioned the diminution in size of the propeller, the diameter being reduced from 5 feet 6 inches in the case of the original screw to three feet in the propeller now fitted—a very small diameter indeed, seeing that in some of the recent preliminary trials, the power developed by the engines was 460 indicated horse-power. Another important feature, and one which ought to be exceedingly valuable to torpedo operations, is the protection afforded to the screw by the tube in which it works and the grating in front from floating wreckage. This is an improvement which will no doubt be fully appreciated.

Boats for the French Government

In May 1877 six torpedo-boats were taken in hand for the French Government. They were 87 feet long, and 10½ feet beam, and were to have a speed of 18 knots. It may be remarked that in most of the small boats the propeller was placed abaft the rudder, but this was not the case in the larger vessels fitted for rougher water. The last-named French vessels were to have their frames and plating galvanised below the water. The six French boats were completed and tried in June, 1878, with results varying from 18·1 to 18·9 knots per hour on a three hours' run. When steaming at this high rate of speed the consumption of coal was in some cases as much as a ton per hour, and the bunkers hold but five tons; but, of course, in steaming at moderate speeds, the consumption is reduced. One vessel, it is stated, steamed from Chiswick to Cherbourg in twenty-two hours, on a total consumption of only two and a half tons of coal. The six boats are primarily designed for the defence of Cherbourg, but would be available for any part of the English Channel.

First-class torpedo-boats.

At the present time our Government have two classes of torpedo-boats—a first class intended for harbour and roadstead defence, too large to be carried by ironclads or cruisers as part of their equipment. Two have, however, been sent to Gibraltar and Malta respectively on the deck of a transport ship. The first-class boats are mostly about the size of the 'Lightning.' Twelve of these have been built by Messrs. Thornycroft, and in the latest a speed of 22 knots per hour has been obtained, with about 450 indicated horse-power, on a displacement of 30 tons. The hull is built of Bessemer steel galvanised, or coated with zinc; the deck is also steel, covered in places with cement for foothold. The hatches to engines, boilers

and fore-compartment are fitted with springs, which throw them wide open when the fastening is withdrawn, so as to facilitate egress in an emergency. The hull is very much subdivided by numerous bulkheads and partial bulkheads. The first large compartment is that for the crew, and abaft it is the steering compartment, above which is a conning tower, having at hand the telegraph gear, the voice-pipe to the engine-room, and the starting-gear for the torpedo discharging tube. Abaft this is the boiler compartment, with coal-bunkers at the sides. A peculiarity of the stokehole is that the only exit for air is through the furnaces, by which means is maintained the artificial draught necessary to the rapid combustion required to develope the high power which is essential. The engines are in a compartment next the boilers, and abaft that is the accommodation for officers. The shaft is inclined to the water-line, so as to bring it out aft with its centre only just above the under side of the keel. By this arrangement half the area of the propeller's revolution is below the boat, and thus is obtained the double advantage of a large propeller and a good supply of water for it to act upon. The stern-post abaft the propeller, and to which the rudder is hung, is only attached to the hull of the vessel above water. The thickness of the plates of the first-class torpedo-boat is $\frac{1}{8}$-inch amidships, and rather over $\frac{1}{16}$-inch forward and aft. The total cost is 8,000*l.*, of which 6,000*l.* is for the hull and engines and 2,000*l* for the torpedo-gear.

The supply of first-class torpedo-boats for the British Government has not been a monopoly in the hands of Messrs. Thornycroft. One which was built for them by Messrs. Yarrow, of Millwall, and completed in the early part of 1879, attained the then unprecedented speed of 21·9 knots; two others were purchased from the same firm, who were building them to the order of a foreign Government. Boats built by Messrs. Jarrow and Co., of Poplar, differ somewhat from the above. One recently constructed for the Royal Navy, which has a length of 76 feet, 10 ft. 10 in. beam, and a depth of 6 ft. 6 in., is built entirely of steel on very fine lines, with a curved deck, and is fitted with a pair of high-pressure compound engines, to indicate 400 horse-power. The boat is divided into several watertight compartments. The crew will be under cover, a small cowl on deck supplying fresh air both to them and to the furnaces. Other boats of lower speeds have been built: by Messrs. Hanna, Donald and Wilson, of Paisley; J. White, of Cowes; Rennie, of London; and Maudslay, of London. The last-named was built of brass, we believe, as an experiment to compare in point of duration with

steel boats. It is not apprehended that, when proper precautions are taken, there will be any marked amount of loss from corrosion in the boats built of Bessemer steel, but a very small loss indeed would soon tell on the very thin plates of which these boats are built, and it may possibly turn out that if the existing type of torpedo-boat retains for long a place in the Navy, it may be cheaper in the end to build them of brass than of less durable material. The first-class boat is, as we have said, intended chiefly for harbour defence. One only is armed with the spar torpedo, the others carry each three Whitehead fish torpedoes, which are discharged singly by an air impulse through a tube or air-gun mounted on the fore part of the deck, and commanding a large angle of training.

Second-class torpedo-boats. The second-class torpedo-boat is intended to be carried by large ships of war. The usual dimensions of this class are 60 feet length, $7\frac{1}{2}$ feet beam, indicated horse-power 120 to 150, giving a speed of 16 to $17\frac{1}{2}$ knots, with a displacement of about 12 tons. There are at present between 40 and 50 of these built or building. Each boat carries two Whitehead torpedoes in slings over the side, but arrangements can be fitted for discharging the torpedoes through a tube, thus securing greater precision. The second-class torpedo-boats have $\frac{1}{16}$-inch plates throughout. The boat and engines cost 2,500*l*, the torpedo gear 300*l*. Several of our large ironclads and cruisers carry each two torpedo-boats of this class. One ship, the 'Hecla,' which was purchased two years ago on the slip at Belfast, where she was built, by Messrs. Harland and Wolff, for the British Shipowners' Company, is specially set apart for torpedo service. The 'Hecla' was built for the Atlantic passenger trade, and was purchased by the Admiralty for conversion into a war ship, to become a type of the cruisers which would be obtained from merchant shipowners, and fitted for fighting purposes in the event of war. Subsequently she has been further developed into a torpedo-ship. She is fitted with the most improved means for discharging Whitehead torpedoes, she carries six torpedo-boats, and could also be used for preparing and laying submarine mines.

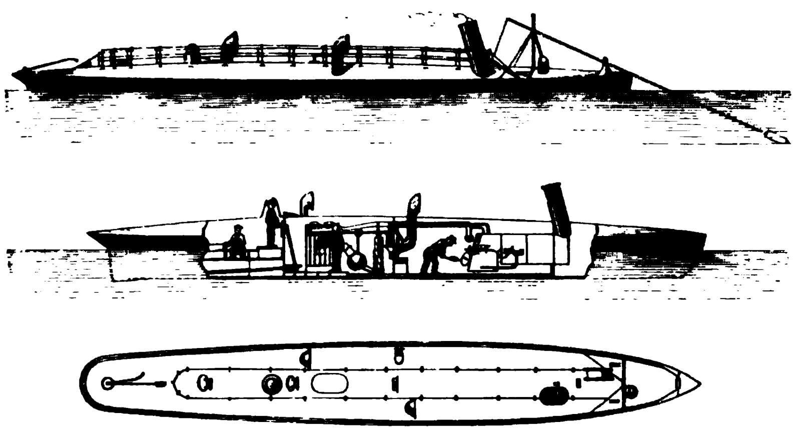
Ships' boats as torpedo-boats. In addition to the boats above described it is also the practice in the Royal Navy to fit the ordinary steam launches and pinnaces to carry Whitehead torpedoes over the side. These boats have, however, one important defect, viz., that their speed does not usually exceed $9\frac{1}{2}$ knots. With a view to having a boat which should be able to do the ordinary dutes of a steam lifeboat and at the same time be available for torpedo service, the Admiralty have recently constructed some boats of a new type. The first six were completed in 1880, by Mr.

J. T. White, of Cowes. They are built of wood, upon the diagonal principle, are propelled by twin-screws, and have realised a speed of over 13 knots. The total weight of these boats, fully equipped, is 152 cwt. They are available for ordinary boat service, would stand more knocking about than the thin light torpedo-boats, and though they have somewhat less speed—an important drawback—it is probable that they would be available at sea in rough weather when the boat built only for speed would not be seaworthy.

Smoke 'ports' and funnel.

There are two drawbacks to the use of existing torpedo-boats for which various remedies have been proposed. The first and most serious is the discharge of smoke and sparks through the funnel, which make known the vessel's presence to the object of attack. The second is the difficulty of steering with the ordinary rudder at the

Figs. 102, 103, and 104.



YARROW'S TORPEDO-BOAT.

very high speeds obtained. In a recent boat built for a foreign Government, Messrs. Yarrow attempted to remedy the first defect by discharging the smoke into side ports, the side being used which was farthest from the enemy, and the port having valves which are kept open by the blast and closed by any large wave. The arrangement was only available in fine weather, and a temporary funnel had to be rigged on other occasions. The same boat has also, in addition to the rudder aft, a rudder placed about ten feet from the bow, both being worked simultaneously by connection with the same steering-gear. The forward rudder can be raised within the vessel, when she is going at her low speed, and when it is not required. It is said that on the trial of the boat, it was found that at high speeds the forward rudder was more useful in steering than the after rudder.

The torpedo-boats ordered by the Russian Government from Mr. F. Schichall, of Elbing, in Eastern Prussia, have the following dimensions: length, 66 feet; beam, 11 ft. 3 in. They are built of steel plate ·12 inch thick. They have three-cylinder compound engines with surface condensers, which run at 380 revolutions a minute, driving a screw four feet in diameter, and indicate 260 horse-power. These boats have actually made the voyage from Elbing to St. Petersburg. At the official trial, which took place in rather rough weather, the boats had to run for two hours with a supply of coal for five hours on board, and under these circumstances an average speed of more than 17 knots per hour was attained. Russian torpedo-boats.

As many as thirty of the Russian torpedo-boats were built by Messrs. Thornycroft. One boat, the 'Wrizw,' which was built in 1877, at St. Petersburg, is of larger dimensions than most vessels of this class, being no less than 120 feet long and 16 feet beam, the speed being 17 knots. Messrs. Yarrow have also built a large boat for the Russian Government, 100 feet long and 12½ feet beam, and carrying an effective armament of six Whitehead torpedoes. In this boat, as in some others of recent design, the tubes used for firing the torpedoes are built into the vessel and covered by a turtle-back deck which slopes up to the conning tower. The steering-gear for the boat and the starting-gear for the torpedoes are concentrated in the tower. The whole of the men engaged in the service are by this arrangement under cover, and are thus protected from rifle bullets. The speed of this boat is 22 knots.

The 'Gloochar' (*Grouse*), one of the hundred torpedo-boats ordered from Russian and foreign builders by the Czar's Government in 1877, was constructed at St. Petersburg. The dimensions are, length 75 feet and beam 9 feet. In most respects the model adopted is that of the boats constructed by Thornycroft in England. The 'Gloochar' has made a voyage from Revel to Sveaborg, steaming a distance of 46 miles at a speed of 16 knots an hour, and has run 32 miles without stopping in less than two hours, expending about 6 cwt. of coal per hour. With the customary supply of a little over four tons she is able to steam for twelve hours at 16 knots and twenty hours at eight knots.

Torpedo-boats have been constructed in Australia. One vessel, the 'Acheron,' and a sister craft the 'Avernus,' were built by the Atlas Company of Sydney, New South Wales, from a design of Mr. N. Self. The 'Acheron' is 80 feet long over all, and 78 feet long on the keel. The beam moulded is 10 ft. 3 in., and the depth 4 ft. 3 in., while the sheer fore and aft is 1 ft. 3 in. The hull is divided into ten watertight compartments. Beginning at the bow, there is, first, Australian torpedo-boats.

the space in front of the collision bulkhead; next, a compartment between that bulkhead and the fore-cabin; and then successively the fore-cabin, the steering and the torpedo compartments, the boiler-room, and the stoke-hole and the engine-room, the after-cabin, and the two compartments astern. As these boats are intended to be used as despatch boats as well as for the torpedo service, more cabin accommodation had to be provided than would otherwise have been required. The hull has iron beams but is plated with steel, the frames being made and set up while the plates were ordered by telegraph from England. The engines are of the compound intermediate receiver type, the high and low pressure cylinders being respectively 11 inches and 19 inches in diameter, with a stroke in each case of 14 inches. The engines are fitted with a surface condenser; the propeller is five feet in diameter, and has three blades; the boss is of wrought iron, while the blades are of hammered steel. On a trial trip the 'Acheron' attained a speed of 16 knots an hour in a heavy sea, the engines making 330 revolutions per minute.

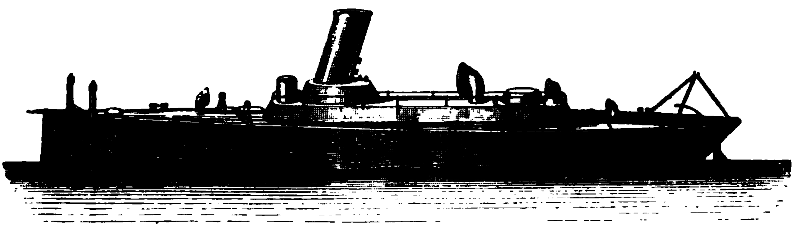
Herreschoff torpedo boats.

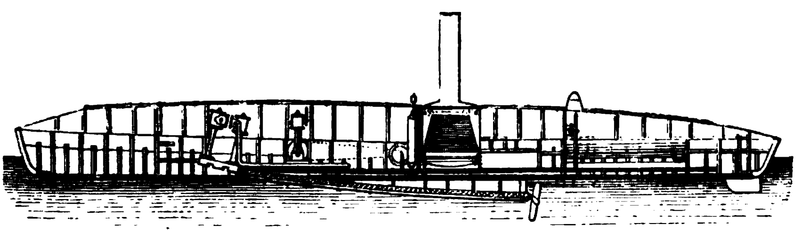
A boat with many very remarkable features has lately been built for the English Government by the Herreschoff Manufacturing Company at Bristol, Rhode Island. She is 59 ft. 6 in. long, with 7 ft. 6 in. beam, and has a composite hull, with timber planking below and a steel skin above, while there is also a steel superstructure covering machinery and men. The lines of the hull are nearly alike at the bow and stern. The boat is propelled by compound engines of the intermediate receiver type, having a 6-inch and a 10½-inch cylinder, each with a 10-inch stroke. There is also another independent engine for driving the fan-blower. The engine is placed well forward in the vessel, and the shaft runs at an inclination through the bottom of the boat. In order, however, to counteract the effect of running a screw with a steeply inclined shaft, the latter is curved throughout its length, so that the after part is brought nearly horizontal. The shaft is of steel, and is kept to the curve shown by being run in a brass tube which is bent to the desired curve, and which forms a kind of continuous bearing from end to end. This plan of employing a spring shaft to communicate the motion to the screw is a bold departure from the ordinary practice, as indeed are many features of the boat, but it appears to answer well, and the friction involved by this arrangement is stated not to be in any way excessive. The curved tube forming the shaft-bearing is securely fixed inside a double-walled copper chamber which projects below the bottom of the boat, and serves the triple purpose of a support to the shaft, a fixed centre-board or false keel, and last, but not least, a surface con-

denser. The keel formed by the condenser being at the centre of the length of the vessel, forms a kind of pivot on which she may be turned. The screw is 38 inches in diameter with 5-feet pitch, and is situated more than one-third of the length of the boat from the stern. Owing to its position it is of course always working in solid water, and its power of suddenly starting or stopping the boat is thus greatly increased. By reversing the engine the boat can be stopped in three-fourths of her own length.

The rudder, like the screw, is placed in an unusual position, being below the bottom of the boat, but close to the stern. It is perfectly balanced, and is so mounted that it is free to turn in any direction, either forward or backward. The steering wheel is situated

Figs. 105 and 106.





HERRESCHOFF'S TORPEDO-BOAT.

below a small conning-tower, and the motion is communicated from it to the rudder-head by means of a chain and rag-wheel. When the boat is going ahead, the preponderating side of the rudder is towards the stern, as usual, but, when going astern, the rudder is allowed to swing completely round, so as to bring the preponderating part towards the bow. Under these circumstances the steering when going astern is as easy as when going ahead. The boat can be turned in a circle the diameter of which is about three times her own length, or about 180 feet. The weight of the boat with fixtures is six tons, or with torpedoes and stores, eight tons. The speed attained on the trial was 16 knots. Perhaps the most striking peculiarity of the Herreschoff invention is the boiler, or 'steam generator.' This consists of

a continuous coil of wrought-iron steam pipes, arranged in the form of the frustrum of a cone, the coil being placed above a fire-grate, which is encircled by a dwarf wall of fire-brick enclosed within a suitable casing. This brick-lined casing, with the space within the coil itself, forms a combustion chamber, and the whole is enclosed in a double or treble shell or smoke jacket, with an air space or spaces between for insulation. There are two forms of the Herreschoff generator, namely, those of the double and single coil. In situations where it is desirable to combine economy of fuel with moderate width in the generator, a double coil is used; where it is an object to economise height, the single coil is used. In operating this generator water is delivered by the pump into the outside part of the flat coil, which serves as a feed-water heater, its inner end being connected to the top of the main coil, through which the water descends. As the water approaches the bottom, it becomes partly vapourised, and at the bottom of the inner coil the pipe merges continuously into the outer coil, through which the ascending steam and water pass, to be finally delivered into the separator. On its arrival at the separator the water is almost steam. The water being heavier is thrown outward by centrifugal force against the sides of the separator, when it readily falls to the bottom. The steam occupying the upper and central portions of the separator escapes through the passage to the coil, in which it is more thoroughly dried and superheated, and it is then conveyed by the supply-pipe to the engine. A sufficient pressure of steam can be obtained to work the engines of the torpedo-boat in less than five minutes from the order to light the fires.

French torpedo-boats.

In France, as in England and Russia, torpedo-boats are considered indispensable, and fifty have already been purchased. The earlier boats in the French Navy were designed to be armed with spar torpedoes; those of the last type built in France are to carry the Whitehead, and are of 33 tons displacement, and 92 feet long, with a speed of 19 to 20 knots. The plates are of steel, and are said to be three to five millimètres (roughly, two or three-sixteenths of an inch) thick.

Danish torpedo-vessel.

The Danish torpedo-ship 'Tordenskjold,' is of a very peculiar design, consisting of a turtle-shaped under-ship, with an arched deck armoured with 3½-inch steel plates. The under-ship has a double bottom, and is divided into twenty-three watertight compartments, in which the boilers and engines are placed, as well as hydraulic machinery for working the exceptionally heavy ordnance with which the ship is to be armed. From this under-ship what may be called a middle-ship arises, the interior of this being divided into 40 watertight compart-

ments, which are filled with cork, to ensure the stability of the vessels even after the sides have been pierced by projectiles. Above this middle-ship or intermediate portion stands the upper-ship, in which the crew will be berthed in commodious and well-lighted and ventilated 'between-decks'; and the deck-covering, which forms the upper deck of the whole vessel. In the fore-part of the upper-ship is a turret, armoured with steel plates eight inches thick, in which a 35½-c/m. (14-inch) Krupp gun, weighing 46 tons and firing a 1,000-lb. projectile, will be mounted, while four lighter Krupp guns will be placed elsewhere on the upper deck. The vessel will also carry two torpedo-boats, and will be fitted with apparatus for discharging Whitehead torpedoes above the water-line. The length is 215 feet, the breadth 42 feet, draught of water 14 feet forward and 15 feet aft, and the displacement 2,400 tons.

Argentine paddle-wheel torpedo-vessel.

On October 18, 1880, there was launched from the shipbuilding yard of Messrs. John Elder and Co., Fairfield, Govan, a steel paddle steamer, the 'Maipu,' for the Argentine Republic. The vessel is intended for torpedo warfare, but may also be used for surveying purposes. The principal dimensions are:—Length between perpendiculars, 240 feet; breadth, 30 feet; depth, moulded, 14 ft. 3 in.; her tonnage, B.M., being 1,062 tons. The propelling machinery consists of two diagonal oscillating engines, one working each paddle-wheel. For manœuvring purposes these are made capable of being connected or disconnected at will. The high-pressure cylinder of each engine is 30 inches in diameter, and the low-pressure is 56 inches by 5 ft. 6. in. stroke. Steam is supplied by four steel single-ended boilers, working up to 75-lb. pressure, and capable of driving the vessel at a speed of 15 knots an hour easily. The 'Maipu' has two pole masts, with light schooner rig, and has a ram bow. The whole of the 'tween decks is fitted up for the accommodation of the officers and crew; the magazines, store-rooms, shell-rooms, etc., being below. One 40-pounder Armstrong steel breech-loading gun is mounted forward, while one Hotchkiss 5-barrelled 4-pounder gun, and two other mitrailleuses are carried aft. In addition to these the armament will consist of spar and Whitehead torpedoes.

Section IV.—*Torpedo Experiments.*

The 'Oberon' experiments.

Experiments have been carried out with the view of ascertaining the maximum distance within which the engines of an enemy's vessel might be placed *hors de combat*, if indeed the ship herself might not be destroyed, by the explosion of a submarine torpedo. With this

view H.M.S. 'Oberon,' an old iron paddle-wheel vessel, was adapted for the experiments which were to be directed against her. She was fitted with an outer skin of iron plating up to the line at which the armour would commence, the outer skin being composed of plates $\frac{13}{16}$ of an inch and $\frac{7}{8}$ of an inch thick. The sides and bottom were made of equal strength to those of H.M.S. 'Hercules,' the hull being divided by bulkheads into seven watertight compartments. On board her was placed a condenser fitted with inlet and outlet valves, which were left open. She was also fitted with a Kingston feed-pump valve, which was closed. The water-line was two feet above the condenser. The weight of the hull was brought up to 920 tons. Thus prepared she was moored in Stokes Bay. On her starboard side were fitted 44 crusher gauges, each crusher having $\frac{2}{3}$ of a square inch of piston area, containing a lead cylinder hardened with antimony, with a sectional area of $\frac{1}{12}$ of an inch. Over each side were suspended 18-pounder shot, each fitted with a crusher gauge.

The torpedo consisted of a charge of 500 lbs. of compressed gun-cotton, saturated with fresh water and placed in an iron case of the service pattern. The priming charge was composed of two 9-oz. discs of dry compressed gun-cotton in a waterproof bag, and two detonating fuses in a divided circuit, to be fired in an electric battery. The charge was placed broadside on to the vessel, in 48 feet of water, at a horizontal distance of 100 feet.

When the shock of explosion took place there was a simultaneous upheaval of water, of dome shape, about 100 feet in circumference, from the centre of which arose a column discoloured with mud about 50 feet in diameter, to a height of 90 or 100 feet more. In general terms it may be said that the experiment demonstrated the fact that the hull of an ironclad is practically safe from danger at a distance of 100 feet from a 500-lb. charge of gun-cotton exploded in 48 feet of water, but that the engines are liable to derangement at that distance.

Another experiment was made, the result of which seemed to render it questionable if the 'Oberon' would not have succumbed to the force of the explosion had the inertia been that due to a vessel of equal size fitted with engines and boilers, and fully armed and equipped, instead of that presented by a mere empty hull. The distance in the second experiment was 80 feet. In the third it was 60 feet, and the torpedo contained 500 lbs. of gun-cotton saturated with fresh water. Some live animals had been placed on board, all of which escaped the explosion without injury.

An examination of the 'Oberon's' bottom showed that, although

no appreciable damage had been done, still the limits of safety were being very closely approached.

In a fourth experiment the distance of the torpedo, which, as in previous experiments, was laid on the bottom, and was charged with the same quantity of wet gun-cotton, was 50 feet from the vessel. There was no serious leak and no internal fracture, but a very marked impression had been made on the outer skin by the explosion. The pressure brought upon the plating had buckled it to a considerable extent, and the vertical framing between the inner and the outer skins stood out in bold relief. The chief seat of weakness was the region round the condenser inlet and outlet pipes. If the 'Oberon' had presented 9,000 tons of inertia to the blow, as would a vessel of the size of the 'Hercules,' instead of only 1,000 tons, she could hardly have survived the shock of such an explosion. In a subsequent experiment the same weight of charge was used, but instead of being placed at the bottom of the water, it was suspended below the surface, there being a horizontal distance of 30 feet between it and the side of the hull. Its submersion was 48 feet. The 'Oberon' drew 12 feet of water, so that the absolute distance of the charge from the vessel was over 50 feet. After the torpedo was exploded it was found that she had not sprung a leak, and that the inner skin was intact. At one point the top plates of the double bottom were started about $\frac{1}{16}$ of an inch, letting daylight through. In none of the compartments was the inner skin found to be in any way damaged.

In considering the comparatively slight damage done to the 'Oberon' by charges of 500 lbs. weight, the absence of all encumbrance, whether of engines, armour, or equipment, must be taken into account.

The above experiments may be taken as representing the effect upon a ship of stationary *defensive* torpedoes or submarine mines. Further trials were made with *offensive* torpedoes of different kinds. For these experiments the 'Oberon,' drawing 11 feet, was moored head and stern in a depth of about 16 feet at low water. The torpedoes were exploded at nearly high water.

The following torpedoes were used in the experiments:—

1. A Harvey torpedo containing 66 lbs. of gunpowder, primed with the service bolt and case filled with gunpowder, and ignited by means of a powder fuse electrically. The centre of the torpedo was 9¼ feet below the surface, and three feet from the nearest point of the vessel's side.

2. A rectangular iron case containing 33 lbs. of slab gun-cotton (25 per cent. of water being added) exploded when placed opposite

a frame on the port side. An electric detonating fuse was used. The centre of the charge was four feet from the nearest point of the vessel's side, and 9½ feet below the surface. A service steam pinnace, with steam up, and fitted with torpedo gear, one pole being rigged out, was placed at a distance of 22 feet from the charge.

3. In the third experiment the charge was 33 lbs. of granular gun-cotton. The other arrangements with reference to the position of the ship, and the fittings of the torpedo-boat, were the same as in the second experiment. So far as the action of the Harvey torpedo manifested itself to the eye the effect was insignificant, but it seemed that the torpedo had either loosened some of the bolts, or had perforated some of the plating. With respect to the effect of the two preparations of gun-cotton, the 'Oberon' remained for the space of a few minutes apparently as buoyant as ever, then gradually went down by the stern, and would have sunk completely had there been depth of water sufficient. The slow and gradual submersion showed that no large hole had been punched, but rather that the force of the gun-cotton had produced extensive fissures of considerable length but of small breadth.

The efficiency of the outrigger torpedo, the only *offensive* torpedo which had actually destroyed a ship in real warfare, has been tested by other experiments in addition to those just recorded. In France, in 1877, an experiment was made with the view of trying the swift torpedo-boats specially designed by Messrs. Thornycroft. The vessel operated against was an old wooden frigate, the 'Bayonnaise,' of about 2,000 tons. The experiment terminated in her practical destruction. A torpedo charged with 33 lbs. of damp gun-cotton, and carried at the end of a steel spar about 40 feet in length, was exploded against the side of the ship at the depth of about 8½ feet below the surface of the water. The launch attacked the 'Bayonnaise' at a speed of about 14 knots an hour, the frigate being towed by a steamer at the rate of about six knots an hour. At the instant before the blow was struck it was found necessary to reduce the speed of the launch. The explosion was followed by a shock and a large wave, which flooded the launch and drove it back for a considerable distance. The damage done to the 'Bayonnaise' was of such a nature as to have sunk her immediately, had not the precaution been taken of previously loading her with empty casks.

The 'Bayonnaise' experiments.

Bullet holes through fast torpedo-boats.

Another curious experiment has been made with a torpedo-boat of similar type. In the engagement between the torpedo-boats and the Turkish river monitor on the Danube, it had been observed that one of the former, though pierced by bullets, did not sink, whereupon

the idea suggested itself to the builders to make a bullet-hole in one of their new boats, in order to see under what conditions flotation would be still retained. A Martini-Henry rifle bullet was fired through the side about a foot under water in the stoke-hole. When the boat was at anchor the water entered in sufficient quantity to fill a bucket in twenty-five seconds; when she was going ahead less water entered; and when the speed was ten knots an hour immunity was practically secured. The boat in which the experiment was tried was 76 feet long, with ten feet beam, and had attained an average speed of 18·9 knots. It seemed that in her rapid progress she drew with her a skin of water which rushed forward with such velocity that it hardly found its way at all into the shot-hole, and acted as a plug in resisting the pressure of the outer body of water beyond the skin. The hole was a little more than ¾ of an inch in diameter. A shot from a large gun would doubtless have been more dangerous, but the effect of continued and rapid movement in keeping water out of a hull pierced by small projectiles fired from rifles or machine-guns deserves much consideration.

The protection of ships against the destructive effect of submarine explosions has become more and more important, in proportion as improvements have been introduced into the manufacture and manipulation of torpedoes. This protection may be said to assume two general forms, first, defence against mines or stationary torpedoes, and secondly, protection from locomotive or offensive torpedoes. Methods have been devised for the removal or premature explosion of obstructions to a channel. 'Under the guns of a heavy fleet,' says Admiral Porter, 'torpedoes can be raised from a channel at night by men in submarine armour, or the machines may be made useless by cutting the firing wires.' An arrangement of outriggers protruding from a vessel's bow has been used to remove or induce the premature explosion of submarine mines, before the ship herself should pass over them. Protection against torpedoes.

Of late much attention has been directed to the plan of countermining or destroying hostile torpedoes by the explosion of other torpedoes in their vicinity. It has been proved by some experiments carried out by order of the Swedish Government, that the firing of a primary torpedo charged with 150 lbs. of dynamite exploded by concussion two other similar charges, each laid at a distance of 200 feet, and unconnected with it or with each other. During the 'Oberon' experiments a secondary charge of 100 lbs. of disc gun-cotton, saturated with about thirty per cent. of fresh water, was placed in a service mine case, and laid about 120 feet from the main torpedo. Another Counter-mines.

secondary charge, consisting of 50 lbs. of gun-cotton, was secured in a piece of netting, and placed 120 feet in another direction from the primary charge. The two secondary torpedoes were placed on a bed of soft mud 100 feet apart, and neither of their charges was fired by the explosion of the primary charge of 500 lbs. of gun-cotton.

Submarine defences, as shown by experiments later than the one just recorded, now seem to be vulnerable by the attacks of counter-mines, by 'creeping,' and by an arrangement for lifting somewhat similar to the device on an American locomotive called a 'cow-catcher,' by which the electrical contact with the shore is destroyed, or the electrical apparatus in the torpedo itself rendered inoperate. Some experiments tend to show that each counter-mine of the size used in our service is capable of clearing a radius of 80 feet round itself, that one line of counter-mines could clear a channel of 180 feet, and that a couple of lines 180 feet apart could clear a passage 360 feet in width, which would be sufficient to enable a fleet of ironclads to move through in perfect security from torpedo attack. The counter-mine destroys the defences, not by causing them to explode through the concussion, but by simply destroying the electrical apparatus in the mines themselves, and thus rendering them inert. If the defensive mines are placed too close together, there is a chance of the premature explosion of one of them clearing a considerable passage, and thus of itself freeing an entrance to a hostile force. Counter-mines can be either floated in by the tide, or more accurately dropped into place by a steam launch, with no crew on board, steered and controlled by electricity, the current being conducted through a cable, much in the same manner as in the automatic torpedo of Mr. Lay.

It has been proposed that large mortar shells fitted with a fuse, which would ignite their bursting charge under water, should be fired at positions known to be defended by submarine mines. If the bursting charge were of sufficient size, the explosion of these shells might be expected to act in the same manner against the defences as other counter-mines.

An ingenious plan for picking up torpedoes which required examination was devised at Constantinople during the late Russo-Turkish war, and might under many circumstances be advantageously adopted by a force endeavouring to clear a channel mined by the defenders. A projectile, with an anchor or grapnel attached, was fired from a howitzer or mortar, on the plan of the original life-saving apparatus. The projectile carried with it a line, and thus became a 'creeper,' which could be worked by boats' crews at a safe distance from the explosion of the mine, or from the fire of the protecting artillery.

Torpedo-nets.

Protection against locomotive torpedoes, either those containing their own motive power or those attached to the extremity of outriggers on fast steamboats, is less easy to secure. When the torpedo attack is likely to be made against vessels stationary in their own harbours, or blockading those of the enemy, the best chance of success for a system of protection seems to lie in arranging round the ships a series of obstructions, similar to that adopted on occasions by the Turkish naval officers during the late war.[1] A ring of spars may be moored round a ship; or boats, connected together by chain or hemp cables, may be anchored so as to form a ring, through which the torpedo-boat must pass in order to reach the object aimed at. Experiments have been carried out in England to test the value of a protecting arrangement rigged out from ships, composed of the swinging booms and other spars protruding at intervals from the side, and connected by hawsers, from the outer end of which a network of rope reaching to a certain depth is suspended. The knowledge derived from previous experiments, that the destructive effect of a torpedo explosion decreases rapidly in proportion to the distance at which it occurs from the object attacked, has in some sort permitted a standard of length to be established for the protruding spars. It was found that a full-rigged ironclad, using her own spars, could supply materials for constructing this kind of defence from the ordinary stores. Experience in actual war, however, has proved more than once that no obstruction is likely to give security unless an unceasing look-out is kept up from the vessel threatened. Two methods of protection against torpedo attacks are proposed, namely, the employment of fast satellites to ward off and engage the torpedo-boats before they can get within range, and the erection of what may be termed crinoline frames of the kind just described around the ships themselves, by means of which the rush of the torpedo would be arrested before striking the hull. Various forms of nets, composed of alternate lines of bars and chains, have been tried, but the size and power of torpedoes have so increased that it is frequently found that nets afford little or no protection. A chain-net formed of chains $\frac{5}{16}$ of an inch thick was easily perforated by a Whitehead torpedo. The great fault of many nets is their extreme rigidity, which opposes an almost solid wall to the impact of the torpedo, and thus the bars are generally snapped. Better results have been obtained from a kind of matting

[1] The obstructions devised by Admiral Hobart Pasha consisted of parallel ropes, fitted like hammock girtlines or clothes'-lines, stretched between pairs of boats held by string grapnels in a ring round the ships, the ropes being supported at intervals by small buoys.

composed of strands of wire about half an inch in thickness worked into open meshes. It possesses considerable flexibility, and as it yields when struck, the force of the torpedo is arrested not suddenly but gradually, and, on losing its momentum, it is driven back by the recoil of the mat. During the experiments, a torpedo thus forced back twirled its tail off, without inflicting any injury on the matting.

Use of electric light.

Torpedo attacks are, as a rule, most likely to be made when darkness or fog prevails, and this increases the assailant's chance of approaching unperceived. It has, therefore, been considered desirable that ships should be provided with some plan of illuminating the waters in their neighbourhood. The electric light, arranged to cast a cone-shaped beam in any required direction, has been employed as well as other systems of artificial illumination. From the ship using the light it is easy to discover the approach of even the fastest torpedo-boat, the hull of which is made to appear with sufficient clearness to enable aim at it to be taken by small arms or machine-guns. There is, however, one great drawback to the use of the electric light on board ship. The light itself affords a mark to an opponent. If, therefore, the latter can cover the attack of his torpedo-boats by a brisk cannonade, either from his ships or from other boats, it would not be difficult to extinguish the light, unless indeed it were thrown on the advancing assailants by a system of reflectors, so arranged as to conceal the position of the machinery producing it. It has been found by actual experiment that by the expedient of placing in rear of the sights of a gun a piece of white paper, and training the gun until the shadows cast on the paper by the sights are actually in one, the gun is accurately laid upon the source of light. Until some method of throwing the beam indirectly to illuminate the water over which the torpedo-boat must advance be discovered, it is evident that the electric light, when the enemy can bring guns into action, must be used with great caution.

Indication of the approach of a torpedo-boat.

Experiments have also been carried out with the object of ascertaining how near it is possible for a torpedo-boat to approach an enemy in the night-time, without being discovered either by the noise of its machinery or by the glare of its fires. The 'Speedy' gunboat, stationed at Spithead, represented the enemy. The torpedo flotilla consisted of the 'Lightning' and of four steam launches, and met at a rendezvous about four miles off. Two of the launches were tried with reference to the means adopted for concealing the glare of their fires and two with reference to noise, while the 'Lightning' was tried both as to noise and glare. Smokeless steam navigation coal was used in each instance. There was no moon, but the air was perfectly clear,

and the sea was so perfectly calm that the slightest noise could be discovered. The 'Lightning' led the attack, and was followed at intervals of a quarter of an hour by the torpedo-launches. She was discovered five minutes before she passed the stern of the gunboat by the sound of the working of her engines. Of the two launches to be tested for glare, one was fitted, for the purpose of concealing the light from the furnace, with 'venetian' ashpit doors of peculiar construction, while the other was provided with a vertical tube for the passage of air to the ashpit, thus removing the necessity of having open doors. There was no glare from the ashpit of the former; but her approach was detected by the glare from the funnel produced by the exhaust. Of the launches tested with reference to noise, the motive power of one was furnished by a noiseless engine, the other was fitted with a 'quieting' exhaust. In the case of the former its approach was discovered by the glare before the noise of the machinery could be discovered, while in the case of the other there was no glare at all, its approach being indicated by the noise of the machinery, but it had arrived within a minute and a half of the gunboat before it was discovered by observers intently on the look-out. These experiments appear to prove that the construction of a perfectly noiseless and invisible torpedo-boat is within the bounds of possibility. Propelling machinery worked by compressed air, as in the submarine locomotive torpedoes, would in all probability not be open to the objections due to glare and noise, from which the present steam-propelled boats are not free.

Section V.—*Lessons to be Learned from the actual Use of Torpedoes in recent Wars.*

The effect upon a ship's hull of a torpedo when exploded in earnest, and the chances of succeeding in bringing it about are eminently deserving of consideration in a work chiefly devoted to an examination of the floating *matériel* of fleets. Two important essays on these snbjects have lately appeared—one from the pen of a French, the other from that of a Russian officer—and these are here presented to the reader in a summarised form.

In the *Revue Maritime* of July 1879, Lieutenant Chabaud-Arnault, of the French Navy, published a paper on 'The Employment of Torpedoes in Boats against Ships.' The first part of the essay is taken up by an historical account of the affairs in the late American and Russo-Turkish wars, in which offensive torpedoes were used. In the second part are contained the deductions which, it seemed to him, Lieutenant Chabaud-Arnault.

may be made from these events. He first made enquiry into the merits of the *personnel* of the Turkish and Russian navies, and concludes that the steadiness and devotion on both sides were about equal.

He then proceeds as follows: 'When the Americans for the first time employed the torpedo as an offensive weapon in boats, the latter seemed to be threatened with three dangers, which would, it was believed, inevitably lead to their destruction. If the percussive effect of the torpedo did not stave in their hulls, if the spray thrown up by the explosion did not fill them and extinguish their fires, how could they escape from the hail of shot and shell and rifle-bullets directed at them by a vigilant enemy? After the American War of Secession, after the destruction of the submarine boat commanded by Lieutenant Dixon, of Lieutenant Cushing's steam launch, and of the "David," which tried to sink the "Ironsides," it was generally thought that a boat carrying a torpedo which attacked an enemy's ship was doomed to certain destruction. Soon, however, many experiments proved that a well-built torpedo-boat had nothing to fear from the concussion to her hull nor from the column of water thrown up. The combats of Matchin, Sulina, and Soukoum Kalé amply confirm these results; indeed, several of the boats used by the Russians, particularly at Matchin, were decidedly inferior in regard to their watertight fittings to the fine boats specially constructed for manœuvring torpedoes. Not one of them, however, sank in consequence of the explosion of the weapon which she carried. If Lieutenant Dixon's submarine boat and the "David" which were directed against the ironclads were less fortunate, it should be attributed to their defective construction. With regard to Lieutenant Cushing's launch, it seems proved that her loss was caused by a shot fired from the "Albemarle." The fire of guns, machine-guns, and rifles by the enemy is, therefore, the only real danger that torpedo-boats have to dread.'

Disasters to torpedo-boats.

'Before the Turko-Russian war many seamen considered the risk so serious that they doubted the efficacy of an attack directed by boats armed with torpedoes, not only by day against a vessel under way, but even at night against a ship at anchor, and well-guarded. We may now believe that in none of these attacks did a suitably constructed torpedo-boat incur any exceptional danger. What then do we learn from the actions related on the first part of this paper? Leaving out of consideration the boats whose crews, although present on the field of action, did not take part in the fighting, neglecting also the two American boats which were only lost owing to their bad

construction, we see that during the Turko-Russian and the American Civil Wars sixteen torpedo-boats have attacked enemy's ships with contrivances of different kinds. Now of these sixteen boats two only were destroyed, Lieutenant Cushing's launch and that of Lieutenant Poustchine, whilst this latter officer asserts that he sank his boat with his own hands, as an accident which had happened to the engine after the action would have inevitably caused her to fall into the hands of the enemy. Several of the Russian attacks were carried out under very unfavourable conditions near Matchin. The "Xenia" launch remained motionless for ten minutes under fire before attacking the monitor "Seifi." In the action of Sulina the torpedo boats No. 1 and No. 2, after having cleared the rope obstruction near the 'Idjaljeh,' were detained a comparatively long time before they could free themselves from the meshes which would have disabled their propellers. Off Soukoum, the four boats which engaged the "Assar-i-Chefket" were perceived when tolerably far off by the Turks. In the affairs of Rustchuk and Nicopolis by daylight the Russian officers assert that in the second attack the "Choutka" was exposed for one hour to the fire of the enemy, a well-armed and well-commanded Turkish monitor; and yet the "Choutka" succeeded in escaping, together with her consort, the "Mina." The torpedo-boats employed near Matchin, off Sulina, and off Soukoum Kalé were equally fortunate.

'Recent experiments have shown that a rapid steam-launch, perforated by one or more projectiles of moderate size, will not sink if she continues at full speed. This fact has been confirmed on several occasions during the Turko-Russian war. The "Choutka" was pierced at Rustchuk by a considerable projectile, and at Nicopolis by a shot from a machine-gun. On both occasions she kept afloat by continuing at full speed. Near Matchin the Russian launch "Djignite," of only moderate speed, was struck by a shot which made a hole in her after-end; she had time, nevertheless, to run ashore on the bank, and was able to stop the leak in a few minutes.

'Will the crew of a torpedo-boat be more in danger than the hull from bullets, shells, and heavy shot of the enemy? An examination of the various combats of the Turko-Russian war enables us to answer this question. Let us first take the night attacks. Only one man was wounded in eleven torpedo-boats which took part in numerous attacks. In the comparatively protracted engagements at Matchin and Sulina not a Russian was hit by Turkish projectiles, though several of the launches commanded by Lieutenants Doubasoff and Zatzarevni were protected by incomplete screens or roofs. In each of the two

affairs which took place by daylight at Rustchuk and Nicopolis, the assailants counted four or five wounded, but there, too, they were but slightly protected against rifle fire.

Attacks on ships at anchor.

'It may be asked how it was possible that the "Choutka" and her crew on June 23 escaped the continuous and prolonged fire of the monitor which they had so rashly attacked? The gunners of the Turkish vessels were perhaps not very well drilled, but their riflemen have never been thought less expert than others; and some of the Turkish ships, especially those commanded by Frankish officers, proved during the course of the war that they were capable of doing excellent service. Thus, as experience now shows, an attack attempted by night or day by a well-constructed torpedo-boat against a ship at anchor or in motion, presents no exceptional dangers either for the boat or the crew.[1]

'In all coast warfare the employment of torpedo-boats is therefore possible, but will it be effectual? The first part of this paper shows that of fourteen attacks made by torpedo-boats, four have caused the destruction of a ship, three have done more or less serious damage to the enemy, and the others appear to have produced no result at all. Now in each of those affairs the *personnel* and the *matériel* exposed by the assailants to the enemy's fire were very inconsiderable—ten or twenty men, two or three boats worth together from 600*l.* to 2,500*l.*; and it is with forces so minute that once out of three times they have succeeded in destroying a ship manned by hundreds of men, and the cost of which can be counted by hundreds of thousands. Is not such a result conclusive?

Examination of the manner in which the attacks described have been conducted.

'Let us examine the conditions under which the attacks described above have been made. The American torpedo-boats employed during the War of Secession were all, as it has been already said, singularly defective. Several of the Russian boats employed during the late struggle with the Turks were capable of much improvement, and the torpedoes employed by the assailants were not always provided with the best means to render them effective.

'The towing torpedo of the "Tchesmé" was not ignited in the first affair at Batoum, and not even in that of Sulina. Again, at Sakoum the explosion of three torpedoes, probably of a similar class, only caused very insignificant damage to the Turkish armourclad "Assar-i-Chefket."

[1] The reader may be referred to the chapter on guns to see how enormously the power of machine-guns has been increased of late. A committee of Dutch officers has recently reported that 'A torpedo-boat attack by day, if carried out under the fire of properly served Hotchkiss guns, has no chance of succeeding.'

'There is another question. The Russian crews were excellent, but were their torpedo-boats always handled in the most judicious manner? In the first affair of Matchin four boats were under the orders of Lieutenant Zatzarevni, but only one, the "Tchesmé," tried to explode its torpedo. This therefore was not a very serious attack. If the Russian boats had directed a simultaneous and combined assault on the Turkish ironclad attacked by the "Tchesmé," would the result have been the same? On the Danube, near Matchin, it was Lieutenant Doubasoff's intention to engage in succession each of the enemy's ships, using only one boat at a time; hence three of the Russian boats remained motionless for ten minutes under the fire of the Turks. Would it not have been more certain and less dangerous to attack at the same time the "Seifi," with the "Cesarewitch" and the "Xenia," and the Ottoman armoured gunboat with the two other torpedo-launches?

'The affairs at Rustchuk and Nicopolis deserve an especial examination. An attack of the kind made in broad daylight on a vessel under steam has not the same character as a night action. In the latter the first object of an assailant is to surprise a ship which is motionless. Strictly speaking a single boat is enough to obtain success, as is proved beyond dispute by the destruction of the "Housatonic" and the "Albemarle." In the other case, on the contrary, it is necessary to engage an enemy on the look-out, who can see the approach of his foes from afar and can manœuvre with rapidity. Therefore several torpedo-boats should combine their efforts against one ship, to distract his attention and increase their individual chances of success. The attacks of the "Choutka" and the "Mina" were consequently almost inevitably condemned to failure, for in an action like that of Rustchuk or Nicopolis the concurrence of at least four boats would appear to be necessary. Thus, the torpedo boats of America and Russia have made the greater number of their attacks under conditions which were not favourable to their weapons. This consideration renders still more apparent the value of an arm with respect to which the actual experience of battle records one overwhelming success to every two checks.

'We have seen that in each of the affairs at Rustchuk and Nicopolis the Russians had four or five wounded. In nearly all their night engagements, on the other hand, they had not a single man hit by the enemy's fire. This fact shows clearly that while ordinary steam launches can surprise a ship during darkness, an attack by daylight requires specially constructed boats of great speed, very handy, presenting the smallest possible mark to the enemy's riflemen, and

having the crews completely protected against musketry fire. Bullets and machine-gun projectiles may perforate the boat, but from the experience obtained in the Rustchuk and Nicopolis actions we learn that if the engines are uninjured, it will escape being wrecked by keeping at full speed. Therefore great lightness of hull, high speed under steam and in manœuvring, small dimensions, protection against rifle fire at least for the engines and the stations of the crew, seem to be the chief conditions which should be fulfilled by torpedo-boats specially constructed for action.' The writer next says that the experience of the Turko-Russian war should lead us to reject absolutely the use of towing torpedoes in boats.

Outrigger or spar torpedoes. The actions of which some account was given at the beginning of this article show three instances in which the success was complete out of ten attacks made with the outrigger torpedoes. But, as we have seen, the torpedo-boats used by the Americans during the War of Secession were very defective; and the affairs at Rustchuk and Nicopolis took place under conditions specially unfavourable to the assailants. The destruction of the 'Housatonic' and that of the 'Seifi' show that an outrigger torpedo is an arm of terrible effect during the night against ships at anchor which are not protected by an exterior circle of obstructions. The loss of the 'Albemarle' and the action off Sulina show that such a defence is not always sufficient. We know in fact that during the night of June 10–11, 1877, the Russian boats of Lieutenant Rojdestvensky and Poustchine cleared the obstructions which surrounded the 'Idjaljeh.' If their torpedoes did not destroy the ship, it was because they were either struck by a projectile or encountered some obstacle inside the barricade arranged by the Turks. This barricade was possibly, or even probably, the first cause of the failure of the Russians, for it delayed them for some minutes under the fire of the 'Idjaljeh,' and produced amongst them a momentary disturbance which prevented them from manœuvring their torpedoes with all the coolness desirable. Besides, however rapid may be the motion given to a spar torpedo, the greatest difficulty will always be experienced in submerging it during the short space of time taken by the boat to traverse the distance between the enemy's ship and his circle of obstructions or stockade. In the daylight affair at Nicopolis, the booms and nets of the Turkish monitor under way opposed an insurmountable barrier to Lieutenant Niloff's boat. Indeed, the chief objection to the use of the outrigger torpedo is its comparative powerlessness against a vessel protected by exterior obstructions.

'The Russians attribute the premature explosion of the two tor-

pedoes directed against the "Idjaljeh" to the blow of a projectile. At Rustchuk the "Choutka's" torpedo, at Nicopolis the "Mina's," could not be ignited, according to the Russian officers, because the conducting wires had been cut by shot. Ought we not to look for the explanation of these four failures to the defects of the weapons used by the Russians, in the too great hurry of their manœuvres, or in some mistake made when under the fire of the enemy? In fact, experiments prove that rifle bullets and machine guns cannot ignite a torpedo unless its priming is hit direct, and moreover conducting wires are too small a mark for musketry; besides, nothing prevents these wires from being protected by the torpedo spar itself. If absolute reliance can be placed on the Russian reports, a truly extraordinary chance caused—on four different occasions—accidents which can be more easily accounted for by the fallibility of even the best-trained and bravest men. We cannot, therefore, consider the danger to which outrigger torpedoes are exposed by the enemy's fire as a serious objection to their use.

Whitehead torpedoes.

'Unfortunately we have only been able to cite two actions in which the assailants used the Whitehead torpedo: one of these failed, the other was a complete success for the Russians.[1] What did really take place during the second affair at Batoum? Captain Chardonneau thinks that the "Tchesmé's" Whitehead encountered a rock; but as this torpedo was launched only sixty yards from the Turkish armour-clad, it must be supposed that the ship herself was very close to the reef, where the smallest change of position might have exposed her to the danger of grounding. It is not probable that her captain would have chosen, in the extensive roadstead of Batoum, a position so full of peril. Are we to suppose that the Russian torpedo struck against submarine obstructions laid down by the Turks? The latter would, no doubt, have been able to attempt some such plan of defence, but no document makes even an allusion to them.[2]

'We must look elsewhere, therefore, for the causes of the failure of the Russians, and it is important to observe that, when they attacked, the night was very dark, and they might have made an error in estimating the distance which separated them from the enemy. All seamen, indeed, are aware that in profound darkness the hull of a ship suddenly coming in sight appears to be of enormous length

[1] On this point see Hobart Pasha, *North American Review*, vol. cxxvii., pp. 386-387. It is very doubtful if this success ever occurred.

[2] As before observed, in notes, this event probably did not take place at all. The belief that it did is most likely owing to some mistake of the kind alluded to in the next paragraph.

and height out of water. The Russian officers assert that they followed, on the water, the track of the "Tchesmé's" torpedo till it burst on the beam of the Turkish ship; but the setting of the Whitehead is one of the most delicate operations, and when every care is taken they do not always follow a straight line. It is therefore quite possible that the Russians launched their torpedoes at a much greater distance than sixty yards from the Turkish armourclad, and that the former described a curve and passed astern of the ship, running on the reefs of the neighbouring shore. This supposition appears the more admissible since, according to the reports of the Russian officers themselves, the "Sinope's" Whitehead ran towards the after-part of the Turkish ironclad.

'In addition, the system adopted to launch the "Tchesmé's" and the "Sinope's" torpedoes were probably defective; a moveable tube under the boat's keel or the expedient of a raft in tow does not strike us as a convenient apparatus for pointing a Whitehead torpedo. Had the Russians altered these arrangements at the third affair at Batoum? We are not aware, but the rapidity with which the Turkish vessel sank[1] permits the supposition that the Whiteheads launched by the "Tchesmé" and "Sinope" on that occasion both struck the object at which they were aimed.

'We see that on the Danube the Russians made no attempt to use fish torpedoes. Indeed, rivers, sea coasts subject to strong tides, and all places where there are rapid currents, are essentially unfavourable to the employment of these machines, even against ships at anchor. Boats, launching tubes, and torpedoes are all exposed to too many external influences, varying every moment, for the aim to be any real guarantee of accuracy. A rough sea also makes the firing of a Whitehead torpedo very difficult or impossible. Finally, the difference between the density of sea water and of fresh water may cause an important obstacle to the use in rivers of Whitehead torpedoes which have been regulated and tried in seaports.

'Thus deviations, arising from an incorrect estimate of the distance, from defective setting of the steering-gear, from inaccurate pointing of the machine, and external influences acting on its course or immersion, all these are serious difficulties inherent in the use of Whitehead torpedoes in boats.

'Based chiefly on the experience gained during the Turko-Russian war, the preceding discussion enables us to define the circumstances which appear suitable in some cases for the effective use of

[1] Judging from Hobart Pasha's account, no Turkish ship of war was sunk at Batoum. See previous notes.

the outrigger torpedo, in others for that of Whiteheads, first against a ship at anchor and then against one under way.

Comparative efficiency of the outrigger and the Whitehead torpedo.

'When a ship is moored in a strong tideway it is very difficult to form a barricade round her water-line, or even a good system of defence out of booms and nets in connection with her hull. We have just seen that similar circumstances, especially on a dark night with some sea on, also render the firing of the Whitehead very uncertain. Spar torpedoes, therefore, would be employed in preference by boats destined to make an attack; besides, the darkness will more easily permit the latter to elude the look-out of the guard boats and the sentries on board the enemy's ship. When, on the contrary, the night is not too dark, when the sea is smooth and the gentleness of the current allows the ship to be surrounded by external defences, the employment of the Whitehead offers a fine chance of success, which may be looked for in vain from outrigger torpedoes.

'The opportunity of attacking a ship under way with torpedo-boats may occur either by night or by day. We have no experience to guide us as to the probable success of the Whitehead under such circumstances. But the affair at Nicopolis shows that a vessel of moderate speed may effectually be secured against the explosion of outrigger torpedoes by means of a system of booms and nets. In such a case the use of the Whitehead is naturally indicated. It must, nevertheless, not be concealed that the speed of the enemy's vessels adds a considerable element to the external causes which render their flight from boats very uncertain. On the whole, until we have more experience, it would seem wise to include in flotillas intended for coast defence, some boats armed with spar torpedoes and others with Whiteheads. In conclusion let us make use of an illustration by the accuracy of which we have been struck; the spar torpedo is the dagger which, at the risk of his life, a determined man will plunge into the heart of an enemy not protected by a stout coat of mail; the Whitehead torpedo is the perfected bullet which can be easily projected from afar and can kill the enemy on his path, but which also often misses the object aimed at.

Defence against torpedoes.

'Up to the present we have only examined torpedo-boat actions from the side of the attack; let us see if they give us any useful information from that of the defensive. If the "Minnesota,' the "Wabash," and the "Memphis" were neither sunk nor seriously injured by the Confederate "Davids," they were indebted for it chiefly to the great vigilance of their crews; but the "Housatonic," which was on the look-out, for she slipped her cable at the moment of the explosion, was, notwithstanding, destroyed by Lieutenant Dixon's boat.

The Turkish vessels moored near Matchin and off Soukoum Kalé had guard boats; nevertheless the "Seifi" was sunk, and the "Assar-i-Chefket" only escaped the same fate because of the imperfect character of the machines employed against her. It can therefore be seen that the most perfect vigilance is not always an efficient defence against torpedo-boat attacks. All the affairs which we have reviewed also show in a striking manner the defects, under such circumstances, of a defence depending only on gun and rifle fire. On the other hand, if the "Albemarle" was sunk in spite of the stockade which defended her, we have seen that ordinary ropes stretched round the "Idjaljeh" caused the attempt of the Russians to fail, and that the monitor attacked at Nicopolis probably owed her safety to the booms and nets which were secured to her hull. To the employment of similar modes of defence some will object that a ship liable to be attacked by torpedoes must always be ready to start, but the example of the "Housatonic" proves that this precaution would not be sufficient to carry a ship clear of a swift torpedo-boat. Would not a state of preparation for weighing anchor also be interfered with by a system of booms and nets arranged round the ships? No, for the monitor attacked off Nicopolis made use of this plan of defence even when under way. This fact cannot be too much insisted on, for it has shown practically the possibility of defending externally the hull of a ship under steam, and consequently the necessity of attentively studying this question. We know well that at sea, even at moderate speeds, the use of nets and booms would be impossible; but it would be, as a rule, at the mouths of rivers, in channels and roads, where the water would usually be smooth, that ships would have to protect themselves against the attacks of torpedo-boats.

'Besides, in default of booms and nets secured to the hull a vessel at anchor can under certain circumstances effectually defend herself by means of obstructions secured to boats or to buoys moored around her. It was thus that the Turkish stockade off Sulina was able to defy the attempts of the Russian torpedo-boats. The Ottoman ships collected at Batoum were in a good position to follow this example. Their heads were secured by an anchor out to seaward and their sterns by hawsers taken to the shore; they had every facility for forming a barricade at some yards' distance from their hulls, which were almost immovable. It is, moreover, evident that in tideways and anchorages, where there are frequently shifting winds, a ship swinging to her anchor cannot adopt dispositions of the sort on account of the great space required to swing in.

'Thus the maritime operations of the Turko-Russian war seem

to indicate the following plans as the best for the protection of a ship against attacks by torpedo-boats, combining them according to the circumstances of the case. One watch lying down at quarters throughout the night; machine-guns and guns of small calibre in as great numbers as possible ready loaded and pointed; steam up and cables ready for slipping; a system of booms and nets secured to the ship; a barricade of the same kind as that used by the Turks off Sulina; row boats in support of this obstruction armed with guns or machine-guns; finally, at least 100 yards from the ship and abeam, one or more boats with steam up. It would be their duty to give the alarm, and instantly to go at full speed against the enemy's boats which might seem about to launch Whitehead torpedoes. A vessel defended in this way would not be invincible, but would, we think, have many chances in her favour.

General rules for attacks by torpedo-boats.

'These are the conclusions to which we have been led by the examination of the naval operations reviewed in the first part of this article. Attacks made by torpedo-boats against ships during the American War of Secession and the late Turko-Russian struggle took place under such conditions that their results, in view of the experience acquired, deserve to be taken into serious consideration. Those results appear to establish the following points:—An attack made on a ship by means of torpedo-boats does not require circumstances more exceptional, or devotion more absolute, than any other operation of maritime warfare. A similar attack, in which the assailant only engages with a relatively very small force, offers chances of success sufficient to justify an attempt whenever the opportunity may occur. At night a single torpedo-boat of inferior quality may make a formidable attack on a ship at anchor. The attack made by daylight against a ship under way requires the co-operation of several torpedo-boats specially constructed for the purpose. On all occasions on which a flotilla of torpedo-boats is directed against one or several ships the attack should be simultaneous. The employment of towing torpedoes in boats ought to be given up. Outrigger torpedoes may be employed with advantage from boats to attack, during a very dark night or in smooth water, a ship anchored in a strong current. The outrigger torpedo will, however, succeed, if the ship has good exterior defences. Whitehead torpedoes may be employed in preference when the night is comparatively light, the sea calm, the current very gentle, and when the enemy's ship is supposed to be defended by obstructions or nets. Against a ship under way these two classes of torpedoes may be both employed according to circumstances. It seems, therefore, advantageous to include in

the flotillas for the defence of ports and roadsteads both outrigger torpedo boats and fish torpedo boats.

'Whenever circumstances will permit, a ship at anchor ought to defend herself against the attack of torpedo-boats, not only by means of a good look-out on board and outside, but also by obstructions connected with her hull or by a barricade independent of it, or even by employing both systems at the same time.

'Finally, under certain circumstances a ship under way can defend herself advantageously against torpedo-boats by means of spars and nets.'

Article from the *Mittheilungen*.

In the *Mittheilungen aus dem Gebiete des Seewesens*,[1] the Austrian Naval periodical, an article on 'Torpedo-boat Tactics' has lately been published. Twelve Russian torpedo-boats were kept in commission for the whole of the summer of 1879, and the experiences acquired in the course of their commission have been brought together by Lieutenant Witheft, and discussed at a meeting of officers at the Naval Torpedo School. The following is an epitome of the views then expressed.

In the Amerian war the greater number of the ships destroyed were blown up by defensive, and only a small proportion by offensive torpedoes. From the results of the Russo-Turkish war it appears that offensive torpedoes could be employed with much less risk to the boats using them than might have been inferred from the history of earlier attempts in America. To insure success good *matériel* is required, and the boats must be manned by men trained to the special and hazardous duties expected of them. Every division of torpedo-boats should be trained to conduct an attack without the support or co-operation of any other naval arm.

In the Russo-Turkish war almost every attack was successful when undertaken according to a well-matured plan by a group of boats, and no attack succeeded which was made by a single boat. With regard to equipment, the essential point is, that the torpedo and the boat should, so to speak, form a single weapon, so that the attention of the officers in command may never be divided between the conducting of the boat and the handling of the weapon. In the next place it is most important that the arrangements should be such as to secure instantaneous ignition of the explosive without a chance of a miss-fire.

To hit a target of the size of a ship with the spar torpedo requires no particular dexterity, although the attack often fails from the colliding of the boats engaged. The success of the attack is certain

[1] Vol. vii. No. iv.

if the blow has been dealt home, and the assailant knows exactly what is taking place. The towing torpedo must be reckoned as altogether inefficient. The use of the spar torpedo on the broadside does not, on the whole, commend itself to officers conducting torpedo attacks. Drifting torpedoes are often supplied to boats for several reasons which the author gives, although he believes that these torpedoes cannot yet be accepted as practically effective engines of destruction.

Organisation of attacking force.

From this general view of the *matériel* he turns to the tactics to be employed. 'It must be assumed,' he remarks, 'that the vessel to be attacked is protected with nets or floating obstructions. If a division of torpedo-boats is available, it will be well to break it up into three groups, to each of which a special duty will be assigned. Each boat must confine itself to the particular task allotted to it. The first group is required to remove obstructions protecting the ship attacked. The second group makes the attack. The third group is held in reserve, to render help, and fill up casualties caused in the two leading groups by the enemy's defence. As soon as each group has been completed, and the precise duties assigned to each, the operation must be carried out according to a well-considered and well-defined plan. The boats of the first, or pioneer group, and those of the second will proceed in double column. Those of the reserve will follow astern. The pioneer group, having completed its task, should fall back on the reserve. The attack must be made simultaneously by the boats of the attacking groups. The speed of the combined flotilla must be regulated by that of the slowest boat. The commanding officer of the whole division, who should take his place in one of the boats of the reserve group, must give the signal for the attack.'

Speed.

The flotilla should steam as long as possible at the highest speed of the slowest boat. By this means the attack will be made by each boat simultaneously, the slower boats being stationed accordingly. The engines should be slowed when at a moderate distance from the enemy, and should be put at half-speed when about twenty-five yards from him. By adopting this plan it is possible for the officer in charge of the boats to satisfy himself whether his own spar with the torpedo attached remains uninjured up to the last minute before the blow is delivered, whether it is clear of the spars rigged out from the other boats in the group, and whether the electrical firing gear is in order. The latter should only be used when the automatic gear fails, as may readily happen when the distance has been misjudged, and the torpedo has been fired too far from the object.

The torpedo should be brought under the ship's bottom. If a Whitehead be used care should be taken not to aim at a vessel amidships, for there the armour may be carried down to a considerable depth under water. A spar torpedo may in case of necessity be used against a perpendicular broadside. The effect of the explosion induced by the torpedo striking at an acute angle will, in general, be more effective in proportion as the centre of the charge is brought closer to the ship's side.

From what has been said it will be obvious that, in order to insure a successful result, the attack should be made at least four points before or abaft the beam. For such an attack there would be required four pioneers to clear away obstructions, four boats to make the attack, two boats in reserve, and one for the officer commanding the division, in all, eleven boats.

Chances of success. Even supposing the newest type of torpedo-boats to possess contrivances for closing all apertures immediately, experience proves that officers as well as men prefer to make the attack with open hatches, a circumstance which would, probably, be the cause of some loss of life. The loss is not likely, however, to be severe. The torpedo-boats will advance at a speed of more than twenty knots, and a boat with a speed of ten knots would only require 4·8 minutes to pass over a distance of 1,500 mètres exposed to the enemy's fire. In former times many boat expeditions and boarding attacks, requiring much more determination and involving the probable loss of many lives, have been carried out successfully. The attack by torpedo-boats is in fact a kind of 'boarding attack,' only under far more favourable conditions for the assailants than in the old days, since the cutlass, the boarding pike, and the tomahawk have now been supplanted by automatic firing apparatus. If only five out of eleven torpedo-boats sent forth on an expedition return, they will have succeeded in their task; the other six will only have performed their duty, and their loss will be fully repaid by the destruction of the enemy's ship. Every prudent commander, however, before starting on such an expedition ought to thoroughly consider how far success will compensate for the possible risk.

In the course of the late war the attacks by torpedo-boats were carried out with scarcely any loss on the part of the assailants. In the future we shall have to deal with enemies more determined and alert, and a more serious loss in men and *matériel* must be anticipated. It is, however, to be observed that even when a boat is destroyed during an attack, it does not necessarily follow that the crew should lose their lives.

Day and night attacks.

It is difficult to give any positive opinion as to whether it is best to make an attack in broad daylight. On very dark stormy nights the enemy will generally be more watchful. A single ship can scarcely be defended effectually even in the daytime against a flotilla of torpedo-boats. Even when an enemy has long observed a division of boats coming down upon him and has made every preparation to repel their attack, it does not follow that he will be able to make an effective defence. Hence it would seem that the chances of success are greater in a daylight attack.[1] If a ship is attacked in the night the boats should be painted of such a colour as may be least visible under the electric light. The experience of the Black Sea showed that a light brown or a chocolate colour was the least conspicuous.

The armament of torpedo-boats with machine-guns demands very careful consideration. It would seem that they are of doubtful advantage. In making an attack it will be impossible to open fire with these weapons. They can only be employed with effect against boats to cover a retreat. Explosive rockets of pyroxiline may be found more useful. They have been occasionally supplied to torpedo-boats. They do not load them too deeply, take up little room, and can be used with equal advantage for signalling purposes both in advancing to the attack and in retiring. The explosion of these rockets on board the ship attacked would create no small confusion.

General rules for conducting an attack.

The general conclusions to be drawn from the foregoing observations were summed up by Lieutenant Witheft as follows:—

1. Attacks by single boats are only to be attempted as a last resource.

2. The attack must be made according to a carefully considered plan.

3. The torpedo-boats should be equipped either with the Whitehead or the spar torpedo.

4. The division of boats should be divided into groups, viz., the pioneer group, the assaulting group, and the reserve group.

5. The torpedo should be fired automatically; and only when this plan has failed should the electrical firing apparatus be employed.

6. The spars should be dipped as soon as the boat is at half-speed or stopped. At full speed the spars should be triced up clear of the water.

[1] A reference to the sections of the chapter on guns, in which machine-guns are discussed, will show how formidable these weapons would be to boats attacking in daylight.

7. The attack should be made—at a signal from the officer in command—simultaneously from several points.

8. The speed of the boats before the attack, until they reach the positions which have been assigned to them, should be regulated according to the speed of the slowest boat.

9. The commander of the division should remain in rear with the boats of the reserve group.

10. The torpedo must be brought into contact with the bottom or one of the unarmoured ends of the ship attacked.

In order to be able to apply all these rules effectively in war, it is necessary in time of peace to train every torpedo division to act as much as possible under the conditions which would arise in actual warfare. This could be easily effected if the manœuvres of an attack were practised, according to a predetermined plan, against a fleet at anchor and under way with dummy torpedoes. At the end of the course of instruction an attack might be made, as a test of the efficiency which had been attained, with loaded torpedoes against a towed raft or pontoon.

It is only after much practice that success can be obtained in this new method of warfare. Trials with single boats can only be regarded as preliminary to manœuvres with a whole division. The only way to insure success when a boat is for the first time attached to a division, is *constant practice in making attacks of a similar nature in time of peace.*

CHAPTER IV.

COMPARATIVE STRENGTH AND RESOURCES OF THE NAVAL POWERS.

In the chapter on 'The Classification of Ships of War,' the several qualities considered requisite in the fighting ships of the present day have been enumerated. From that enumeration we can deduce the principles on which an estimate of the floating *matériel* of a maritime power should be based. In computing the total naval strength of a country, all the elements and conditions on which it depends must be taken into view. The strategic position of a maritime power as affected by its geographical situation is a point of the first importance, but it is beyond the scope of the present work and will not be noticed here. The main questions with which we shall endeavour to deal are the effective strength of a navy in ships, armament, arsenals, men and officers, and the means which the country has at its disposal for maintaining and supplementing them. The following scheme will show at a glance the chief elements of naval efficiency.

Elements of naval power.

I. *Matériel.*

Ships :—

- Number.
- Power.
- Condition.

Naval yards :—

- Number.
- Size.
- Position.

Weapons :—

- Comparative efficiency.
- Resources for manufacturing.

Private industries in reserve :—

- Merchant ships fit for war service.
- Shipbuilding establishments.
- Engine and boiler factories
- Gun manufactories.

II. *Personnel.*

Active navy:—

Number of trained men on active service.
Officers.

Reserves:—

How organised and drilled.
Number of officers available.
Resources for recruiting.

Institutions for instructing:—

Seamen and boys.
Officers.
Supplementary, or reserve, forces.

Not only should the executive officers and seamen be taken into account, but also other classes; especially, the engineers and stokers belonging to the active navy, and enrolled in, or available for its reserves. The inquiry will be the more easily pursued if each country is examined separately as to its resources, under the headings given above. In many cases the sources of information are not sufficiently copious to afford the means of making an exact comparison of strength.

Difficulty of making an exact comparison of the power of fighting ships.

Taking the qualities specified in the chapter on classification as essential to the modern man-of-war, attempts have been made to form a rigorously exact estimate of the fighting power of a naval force by attaching a numerical value, or figure of merit, to each ship or class of ships composing it. The grounds, on which rests the *formula* by which the figure of merit is calculated, are often arbitrarily selected according to the particular views of the calculator. The value given to each factor is equally arbitrary. The proper significance of the age of the ship and of the material of which she is built is scarcely capable of arithmetical expression. The values of the expression, even when the composing elements are exactly similar, must be made to vary in the cases of ships of different design according to the predilections of the calculator. In the schemes put forward[1] in which

[1] Though it has not been considered desirable to insert the different *formulæ* alluded to in the text, they may be stated in a foot-note:—

In Mr. Barnaby's formula 'fighting efficiency'

$$= \frac{A \times G \times H \times S^3}{L}$$

where A = weight of armour per ton of ship

G = weight of protected guns and ammunition

this kind of calculation finds a place, the majority of vessels (viz. those without armour) are held to be unsuitable for the application of the *formula*. 'The fighting strength of ships,' says the author of *Die Marine*, 'can only be compared approximately. It may be considered from so many points of view that an accurate formula can be scarcely determined.'

There are, however, several statements which may be made concerning any ship or class, and which would receive general acceptance:— Axioms generally accepted.

(i.) Length of time tells more severely upon a ship built of wood than upon one of iron; several wooden ships are known to be worn out and useless, whilst iron ships of the same or of even earlier date are still perfectly sound.

(ii.) If the armour-plating do not exceed a certain thickness it will not afford adequate protection against the guns now commonly carried afloat.

(iii.) Within certain limits, a small number of guns of high penetrative power will render a ship more formidable than a larger number of less effective guns.

(iv.) Defensive arrangements introduced into the structure by watertight compartments, cells, or double bottoms, increase the efficiency of a ship. As a rule ships of iron are much superior to wood ships in respect to internal subdivision.

(v.) Steadiness at sea, handiness, high speed, considerable capacity for carrying fuel, are elements of efficiency of such im-

H = height of lower port-sill above the water-line
S = measured mile speed in knots
L = length of the ship.

Applying this formula to certain armoured ships, the fighting efficiency has been thus represented:—

Monarch	149·8
Hercules	113·4
Captain	83·3
Vanguard	83·0
Defence	10·9

It is, perhaps, hardly necessary to point out the imperfection of an estimate which makes a single 'Vanguard' more powerful than *seven* 'Defences.'

M. Marchal, of the French Constructors' Department, has devised a much more elaborate formula, in which the fighting efficiency (P)

$$= Z\ (M + O + D)$$

where Z = zone of action
M = mobility
O = offensive action
D = defensive power.

Each one of these factors is composed of several others (see his paper, 'Tableau et classements des Marine Militaire' in the *Revue Maritime*). He represents the efficiency of certain ships as under:—

Inflexible	1000
Duilio	956
Amiral Duperré	904
Alexandra	528
Vanguard	312
Huascar	235

portance that a ship which possesses them to a greater extent than another may be regarded as, in most points, the superior.

(vi.) The tendency of late years has been to increase the thickness of the armour, the weight and length of the guns, and the energy of their projectiles, the number of watertight divisions in the hull, the handiness, the speed, and the coal-carrying capacity. Hence, independently of the greater freedom from deterioration due to recent date of construction, the newer ship may be deservedly credited with most of the advantages arising from the introduction of the later improvements.

Such being the conditions on which fighting strength depends, our calculations must include armour, armament, the material of which the hull is constructed, date of building, and speed. In other parts of the work these details will be fully considered. In the present chapter they will be only used to illustrate the total strength of different navies.

In the following statement of the strength of the chief navies of the world, no attempt will be made to estimate the condition of the boilers. This can only be done satisfactorily by those who have the means of acquiring information concerning foreign fleets, which are not likely to be at the disposal of any private person.

England, *matériel*: armoured ships.

On the active list of the British Navy, including three turret-ships, of which two are stationary at Bombay and one at Melbourne, are the names of fifty-nine armoured vessels. Of these four have wooden hulls. The latest of these wood-built ironclads was launched twelve years ago. Their armour is 4½, 6, and 7 inches in thickness; whilst the 12-ton gun is the heaviest carried by any of them, and one has guns of 6½ tons only. Of the iron vessels, three are of small size, displacing little over 1,200 tons. They are protected by 4½-inch armour with a ½-inch inner skin, and mount only two 6½-ton guns each; they are thirteen or fourteen years old, and are not considered seagoing. Seven, of which the newest are nearly fifteen years old, have only 4½-inch armour, and carry but a small number of the heavy 12-ton guns. In two cases, the extreme speed barely exceeds twelve knots. Three ships, of over 10,000 tons displacement, have 5½-inch armour, but carry only a limited number of guns over nine tons, and none over twelve tons weight. Their extreme speed is high, but owing to their enormous length they are ill-adapted for rapid manœuvres at close quarters. Three of but little later date are turret-ships with only 4½-inch exterior armour and guns of twelve

tons or less. Two ships, more than twelve years old, have 6-inch armour and guns of nine and twelve tons, one having a measured mile speed of upwards of 14 knots. Two, somewhat newer than the last, have as their stoutest exterior armour 9-inch plates, and carry 18-ton guns. The three turret-ships stationed in the Indian and Colonial harbours are but little more recent; they have 7-inch or 8-inch armour, and 18-ton guns. Five ships of like design, and less than ten years old, have 8-inch armour on their sides, carry 12-ton guns, and can steam thirteen knots. Four turret-ships for coast service, nearly of the same age, have the same armour and 18-ton guns. We have three other ships of more recent date with 18- or 25-ton guns, and 10½- and 12½-inch armour.

Two broadside ships, launched less than six years since, have armour of eleven and twelve inches, and both carry 18- and 25-ton guns, their speed being fourteen knots. Nine seagoing turret-ships, of which some are not yet completed, have armour ranging from ten to over twenty inches, parts of it being of the composite steel-upon-iron construction. They carry in their turrets the heaviest guns used in the sea-service. Three ships purchased from the builders, by whom they were being built for the Turkish Government, have 12-inch armour and carry 18-ton and, in one instance, 25-ton guns. In the case of two or three special ships in construction, no final decision has been taken as to the armour or armament.

If we omit all the wooden armoured vessels in view of their generally inferior armour and armament, and the length of time they have been in existence, we may classify the remainder as follows:—

Classified list of British ironclads.

Group I.—Seagoing ships and ships which can be employed on foreign coasts, having armour of not less than nine inches in thickness, and carrying guns of not less than 18 tons.

Agamemnon	Dreadnought	Orion
Ajax	Hercules	Rupert
Alexandra	Hotspur	Sultan
Belleisle	Inflexible	Superb
Colossus	Majestic	Téméraire
Conqueror	Monarch	Thunderer
Devastation	Neptune	

The ships in this class are capable of undertaking extended ocean voyages. The seaworthiness of several ships included in the list has been thoroughly tested on distant foreign service.

Group II.—Seagoing ships with armour in parts, of seven and eight inches, and guns of twelve tons weight.

Audacious	Invincible	Swiftsure
Bellerophon	Iron Duke	Triumph

GROUP III.—Seagoing ships moderately or partially armoured, with armaments of numerous armour-piercing guns of the lighter natures.

Achilles	Minotaur	Shannon
Agincourt	Nelson	Warrior
Black Prince	Northampton	Northumberland

GROUP IV.—Seagoing ships moderately armoured and of comparatively light armament.

Defence	Penelope	Valiant
Hector	Resistance	

Of these the 'Penelope' alone has any armour of six inches thickness. The armament is limited to guns not exceeding nine tons in weight.

GROUP V.—Coast-service turret-ships with 8-inch and thicker armour, and guns of not less than 18 tons weight.

Cyclops	Hecate	Abyssinia
Glatton	Hydra	Magdala
Gorgon		Cerberus

The three ships in the third column are not included in the list of the Royal Navy, but, being available for reinforcing the fleet, their names are given here. The term 'coast-service' has been used as capable of expressing both 'coast-defence' and 'coast-attack,' for both of which services the turret-ships in Group V. may be considered suitable. Two of them, with special fittings for the purpose, made the voyage to Bombay; and one similarly fitted was despatched to Australia.

GROUP VI.—Coast-service vessels of moderate dimensions, armament, and armour.

Prince Albert	Scorpion	Wivern

One of these has crossed the Atlantic; and all carry 12-ton guns in turrets.

GROUP VII.—Small armoured gun-vessels with the lightest armour-piercing guns.

Viper	Vixen	Waterwitch

Two of the above have crossed the Atlantic. The torpedo-ram 'Polyphemus' cannot be included in the same class with any other vessels of the British Navy.

It is not pretended that the above classification indicates with rigorous accuracy the powers of the several ships. It is given, however, as a convenient division of the armoured ships of the British Navy into groups, amongst the components of each of which there is a certain similarity of qualification. On this principle the classification of the floating *matériel* of other naval powers will be attempted. Fuller information as to the capabilities of particular vessels will be found in those parts of this work which are occupied with a discussion of the different questions connected with armoured and unarmoured shipbuilding, and in the tables appended to Volume I.

Guns carried in British ironclads.

In this connection a summary may be given of the offensive armament of the several groups, the reader being referred to the separate chapters on Armour and Guns, and to the tables, for further information on this subject. If we take the ordnance mounted in our ironclads at the present moment—observing that in some of the ships very considerable modifications are in contemplation—we may say that the vessels composing Group I. carry amongst them

Four 80-ton guns
Twenty-four 38-ton guns
Eight 35-ton guns
Twenty-one 25-ton guns (11-inch and 12-inch)
Forty-eight 18-ton guns
Four 12-ton guns
Four 9-ton guns
Eight 6½-ton guns.

Lighter guns are omitted from the enumeration.

Group II. has

Fifty 12-ton guns
Five 6½-ton guns.

The ships in Group III. carry

Six 18-ton guns
Seventy 12-ton guns
Thirty-eight 9-ton guns
Forty-four 6½-ton guns.

Those in Group IV. have

Twenty 9-ton guns
Fifty-six 6½-ton guns.

The armament of Group V. is composed of

Two 25-ton guns
Twenty-eight 18-ton guns.

In Group VI. are mounted

Twelve 12-ton guns.

Whilst Group VII. carries only

Six 6½-ton guns.

The seagoing armoured ships of the British Navy carry a total number of 410 armour-piercing guns, including

Four 80-ton guns
Twenty-four 38-ton guns
Eight 35-ton guns
Twenty-one 25-ton guns
Fifty-four 18-ton guns
One hundred and twenty-four 12-ton guns
Sixty-two 9-ton guns
One hundred and nineteen 6½-ton guns.

The armoured ships for coast-service are armed with

Two 25-ton guns
Twenty-eight 18-ton guns
Twelve 12-ton guns
Six 6½-ton guns,

or a total of forty-eight armour-piercing weapons. The grand total of the heavy ordnance carried by the iron-hulled armourclads of Great Britain is therefore 458. Had the wooden ships, the names of which are still to be found on the list of effectives, been included, this number would have been raised to more than 500.

England, unarmoured ships.

The grouping of the unarmoured ships cannot be arranged on the same systematic plan as the armourclads, unless many details are given concerning each individual which find a more suitable place in the chapters on Ship-building, or in the tables. As a general rule size may be taken as the basis of the classification. The old names 'frigate' and 'corvette' are still retained in the official list, though—as it has been observed in another chapter—they have in reality lost their former significance, and are almost misleading when applied to ships of the modern type. With these explanations we proceed to enumerate the ships constituting the modern unarmoured fleet of the British Navy.

GROUP I.—Unarmoured cruisers of 3,000 tons displacement and upwards :— Unarmoured ships. Group I.

Inconstant	Bacchante	Rover
Shah	Euryalus	Active
Raleigh	Iris	Volage
Boadicea	Mercury	

The 'measured mile' speed of these is in all cases over 14½ knots.

GROUP II.—Unarmoured cruisers of a displacement between 2,500 and 1,700 tons. This group may be conveniently divided into several sub-classes. Group II.

(*a*) The C class :—

Canada	Cleopatra	Constance
Carysfort	Comus	Cordelia
Champion	Conquest	Curaçao

(*b*) The 'Gem' class :—

Emerald	Opal	Tourmaline
Garnet	Ruby	Turquoise

(*c*) The 'Modeste' class :—

Amethyst	Encounter	Sapphire
Diamond	Modeste	

(*d*) The 'Briton' class :—

Druid	Briton	Thetis

The individuals of the above four sub-classes are credited with a speed of thirteen knots.

(*e*) The 'Blanche' class :—

Blanche	Eclipse	Spartan
Danaë	Sirius	Tenedos
Dido		

These have a speed of between twelve and thirteen knots. All ships in Group II. are commanded by post-captains.

GROUP III.—Unarmoured cruisers, commanded by commanders, under 1,600 tons displacement :— Group III.

(*a*) Daphne	Nymphe	Vestal
Dryad		

This class, though of somewhat earlier date than the ships in

other divisions of the unarmoured fleet, belongs rather to the new type than to the old-fashioned class of corvettes and sloops.

(*b*) The larger 'Bird' class:—

Cormorant	Espiègle	Pelican
Doterel	Miranda	Penguin
Dragon	Mutine	Phœnix
Gannet	Osprey	Wild Swan
Kingfisher	Pegasus	

The speed of the above is over ten knots.

(*c*) The smaller 'Bird' class:—

Albatross	Egeria	Flying Fish
Daring	Fantome	Sappho

These have a speed of eleven knots.

The three divisions with their sub-classes perhaps exhaust the entire cruising 'effective' of our unarmoured navy. The smaller vessels of recent design and gunboats are intended, or at least are suitable, only for more restricted employment. There are, however, some cruisers of the older type actually in commission, including the 'Wolverene,' 'Juno,' 'Charybdis,' which might be available for extended ocean service in war, or which could release some of the newer vessels from a limited sphere of duty to act as cruisers. The number of these is not large, and not being of very modern date there is a constant tendency to diminution of numbers. There is yet one class of rather recent construction, and of which some individuals, in point of fact, are scarcely yet completed. This class should not be omitted in an enumeration of the unarmoured modern fleet. Though scarcely available as cruisers, they might do good service in war. Vessels of a similar type are to be found in large numbers in other navies. The newer gun-vessels, to which we have referred, constitute

Group IV.

GROUP IV.—

Linnet	Falcon	Ranger
Swift	Flamingo	Rambler
Arab	Griffon	Algerine
Condor	Lily	

These are between 750 and 850 tons displacement, and have an indicated horse-power of from 720 to 870. Although it is hardly possible to classify them, we must not omit from the present statement several different classes of gun-vessels of older type, and numerous gunboats of modern design.

The unarmoured ships of the newer design carry a mixed armament composed of guns of 7-inch calibre and 4½ tons weight, of 64-pdrs., and of smaller pieces, and in addition, 93 armour-piercing guns of 12 and 6½ tons. If the ordnance mounted in the non-cruising classes were included, the total number of armour-piercing guns above six tons weight would be about 200. The number of lighter pieces is of course very much larger. In the present day, however, efficiency depends only to a moderate extent upon the number of guns carried by a fleet, the real test being their accuracy and power of penetrating armour. The latter will be best seen on referring to the portion of the work specially devoted to the question of guns. Nevertheless the number of powerful pieces carried by the ships of the British fleet must be taken into account, when comparing its strength with that of another Power. **Armaments of unarmoured vessels.**

In the lists given of the several classes of British armourclads no vessels with wooden hulls were included, for reasons which were indicated in an earlier part of this chapter. In the French navy many wood-built armoured ships may still be found which cannot be altogether set aside in a general computation of the maritime strength of that country. A considerable number are of recent construction; the 'Victorieuse' and 'Triomphante,' for example, were launched as lately as 1875 and 1876, and several improvements have been introduced into their design, which are not to be found in ships of the same date as those which were excluded from the effective list of our own navy. Although the French Government has decided to build no more wooden ironclads, we shall include in the total strength of the Navy of France all such ships launched since 1869. **France, *matériel*; armoured ships.**

With these explanations, we proceed to give the force, as proposed in the *programme* drawn up for the reconstruction of the French fleet in 1872.

Iron cruising armourclads:—

1st class, 16	2nd class, 12.

Iron coast-service ironclads:—

1st class, 10	2nd class, 10.

It will be seen that of this total of 48 ships, none were to be built of wood; indeed the programme indicated the practical erasure from the effective list of all wooden armoured vessels. Proceeding as with our own armourclads, we may divide the French fleet into the following classes:—

Group I.

GROUP I.—Seagoing ships and ships which can be employed on foreign stations, having not less than 9-inch armour, and carrying guns not inferior to the British 18-ton gun:—

Amiral Duperré	Tonnerre	Indomptable
Amiral Baudin	Fulminant	Tempête
Formidable	Furieux	Vengeur
Foudroyant	Caïman	Tonnant
Dévastation	Terrible	Requin
Redoutable		

The ten vessels in the middle and last columns are officially designated 'coast defence' ships, and are no doubt intended for coast-service. They can, however, make cruises of some length in the Mediterranean; and they seem nearly as capable of being employed in any naval operations in European waters as the 'Devastation,' 'Rupert,' and others ships of comparatively low freeboard, classed in Division I. of our armourclad fleet. All the French vessels included in Group I., except the last three in the third column, have a 'measured mile' speed of at least fourteen knots. The speed of the 'Vengeur' does not exceed ten knots.

Group II.

GROUP II.—Seagoing ships with armour increasing to eight inches, in certain places, and guns not inferior to the British 12-ton gun.

Colbert (wood)	Friedland	Duguesclin
Trident (do.)	Bayard	Vauban
Suffren (do.)	Turenne	

Three of the above are of wood, but only one of the three was completed prior to 1870; and the majority carry guns of a power not very dissimilar to that of the 18-ton British gun. All have an extreme speed of over thirteen knots an hour.

Group III.

GROUP III.—Seagoing ships moderately or partially armoured, with an armament of numerous armour-piercing guns, some being of the lighter natures.

Heroine.

It is not easy to find in the French navy any ships which are the counterparts of the British ships included in the same group. The 'Heroine,' built of iron, with twelve guns, of which four are only of about seven tons weight, and having 6-inch armour in certain parts, is the only ship in any navy entitled to admission into this division. She has a speed of twelve knots; and is nineteen years old.

GROUP IV.—Seagoing ships moderately armoured. Group IV.

Couronne	La Galissonniere (wood)	Triomphante (wood)
	Victorieuse (do.)	

These ships carry heavier guns than the British ships in the corresponding division. The three wood-built ships have some plates of 6-inch armour. The speed of this class is about thirteen knots.

There are no iron-hulled vessels nor any wooden ships of sufficiently recent date to form a division corresponding to Group V. of the British armourclads.

GROUP VI.—Coast-service vessels of moderate dimensions, armament and armour:— Group VI.

Tigre (wood)	Bouledogue (wood.)	Implacable
Bélier (do.)	Onandaga (do.)	Opiniâtre
	Arrogante	

The above are perhaps not very much inferior in power to the British 'Prince Albert,' and 'Scorpion.' The guns carried by the French vessels are somewhat heavier than the British armaments.

GROUP VII.—Small armoured gun-vessels with light armour-piercing guns. Group VII

Embuscade	Imprenable	Refuge
	Protectrice	

On the whole these are probably somewhat more powerful than our 'Viper' and consorts.

Four small armoured French river gunboats are unclassed.

It should be noted that, as in the case of the British ships, all French ships, which are sufficiently far advanced in building to have their names upon the official navy list, have been included in the classification just given.

The armament of the French armourclads may be thus summarised, noting that ships credited with 32 c/m. (12½-inch) guns in some cases carry only 27 c/m. (10½-inch) guns. The reason is that their designated ordnance is not ready. The ships which have been classed in Group I. carry, or are intended to carry:— Armaments of French ironclads.

Eight 34 c/m. (13⅓-inch) 50-ton guns
Twenty-six 32 c/m. (12½-inch) 38-ton guns
Sixteen 27 c/m. (10½-inch) 23-ton guns.

Guns not counted armour-piercers are omitted from the lists

of this and all the ironclad classes. The 'Amiral Baudin' and 'Formidable will perhaps carry 72-ton guns;[1] and even 100-ton guns have been in contemplation.

Group II. carries

Twenty-eight 27 c/m. (10½-inch) 23-ton guns
Twenty-two 24 c/m. (9½-inch) 15-ton guns
Four 19 c/m. (7½-inch) 7½-ton guns.

The armament of Group III. comprises the following armour-piercing guns:—

Eight 24 c/m. (9½-inch) 15-ton guns
Four 19 c/m. (7½-inch) 7½-ton guns.

That of Group IV. consists of

Twenty-four 24 c/m. (9½-inch) 15-ton guns
Six 19 c/m. (7½-inch) 7½-ton guns.

In Group VI. we find

Seventeen 24 c/m. (9½-inch) 15-ton guns.

In Group VII.

Sixteen 19 c/m. (7½-inch) 7½-ton guns.

Thus the heavy armament of the French armoured fleet is composed of

Two 72-ton guns (for the 'Requin')
Eight 50-ton guns[2]
Twenty-six 38-ton guns
Forty-four 23-ton guns
Seventy-two 15-ton guns
Thirty 7½-ton guns.

or a total of 182 armour-piercing guns. Had the guns of the older wooden hulled ships been included, this figure would have been greatly exceeded.

France: unarmoured ships.

The programme of 1872, already cited, laid down that there should be thirty-four cruisers of the newer type, divided into three classes. They were to be completed in 1885. In order to make the comparison between ships of different navies as exhaustive as possible, the grouping of the unarmoured ships will follow the plan adopted in the case of the British fleet.

[1] The 'Requin,' when completed, will perhaps carry 72-ton guns of steel.

[2] It should be stated that the so-called 50-ton gun is apparently a 47-ton piece; probably its final dimensions are not yet settled.

GROUP I.—Unarmoured cruisers of 3,000 tons displacement and upwards.

Duquesne	Tourville	Duguay-Trouin

These ships have a speed exceeding sixteen knots.

GROUP II.—Unarmoured cruisers of a displacement between 2,500 and 1,700 tons.

(*a*) and (*b*) Classes.

La Pérouse	Forfait	Iphigenie
Villars	Nielly	Naïade
Magin	Monge	A cruiser not yet named
d'Estaing	Roland	

The speed of the above is 15½ knots.

(*c*) Class.

Champlain	Infernet	Sané
Du Petit-Thouars	La Clocheterie	Seignelay
Fabert		

All the above have a speed of over fourteen knots.

(*d*) and (*e*) Classes.

Rigault de Genouilly	Éclaireur	Chateau-Renaud
	Desaix	

The speed of the two vessels in the centre column is given as fifteen knots. The 'Desaix' and 'Chateau-Renaud' are of rather older type and of a date little previous to that of our 'Blanche' class.

GROUP III.—Unarmoured cruisers under 1,600 tons displacement.

(*a*) and (*b*) Classes. These are vessels which, though not of the newest, are still of a comparatively recent type.

Beautemps-Beaupré	Dayot	d'Estrées
Duchauffaut	Ducouëdic	Volta
Hugon	Kersaint	Hamelin
Kerguelen	Segond	Limier
Bourayne	Vaudreuil	Talisman

(*c*) Class.

Bisson	Hussard	Chasseur
La Bourdonnais	Lancier	Voltigeur

These have a speed of twelve knots.

Several ships of older design, some of which may still be tho-

roughly competent to perform certain services in war time, have been omitted from the foregoing enumeration. Such craft as the

Dupleix	Cosmao	Linois
Decrés	Forbin	Hirondelle

and others of similar date are as deserving of consideration as our 'Wolverene' and 'Charybdis,' not to mention smaller classes.

GROUP IV.—The newer gun-vessels.

Boursaint	Bouvet	Parseval

It is doubtful how far these should be separated from the 'Bisson' and 'Hussard' sub-classes. Perhaps the latter should have been ranked with our 'Albatross' group, but taking size and crew into consideration, the division given is as nearly exact as it seems possible to make it. In considering the more antiquated types, it should not be forgotten that from the unarmoured vessels of the French fleet a less extended service would be demanded in war; and, consequently, that many ships, which could not be employed by ourselves, might prove quite efficient for the purposes of the French. That nation has also added largely to the number of its gun-vessels and gunboats, which it has been thought hardly possible to classify.

The armament of the French unarmoured cruisers is also undergoing a transformation. Omitting some ships of less recent construction, they carry twenty-five guns of 7½ inches calibre and 7½ tons weight, which are unquestionably armour-piercers, and 409 lighter guns of 5½ inches calibre.

Germany, *matériel*: armoured ships.

In 1873, the German Admiralty, like that of France, drew up a naval programme. It was proposed that there should be twenty-three armoured vessels of all sizes, twenty unarmoured cruisers, and a larger number of smaller craft. This programme has undergone some modification, but the completion of a powerful force has nevertheless been continuously proceeding.

GROUP I.—Seagoing ships, effective for general foreign service, having not less than 9-inch armour, and carrying guns not inferior to the British 18-ton gun.

Kaiser	Preussen	Würtemberg
Deutschland	Sachsen	D.
Friedrich der Grosse	Baiern	E.

None of these ships steam less than fourteen knots.

GROUP II. has no representative in the German navy.

GROUP III.—Seagoing ships moderately armoured, carrying numerous armour-piercing guns of the lighternatures, is represented by the

König Wilhelm.

This ship has some armour of eight inches thickness, and carries twenty-three guns.

GROUP IV.—Sea-going ships moderately armoured, and of comparatively light armament.

Hansa (wood)	Friedrich-Karl	Kronprinz

The 'Hansa,' though of wood, was completed in 1872.

The coast-service classes are represented by a class of armoured gunboats of 1,000 tons displacement, armed with one 35½-ton gun. They include the

Wespe	Mücke	Krokodil
Viper	Scorpion	J.
Biene	Basilisk	K.
	Camäleon	

The speed of these gunboats is nine knots.

The ships in Group I. carry

Five 30½ c/m. (12-inch) 35½-ton guns
Forty-four 26 c/m. (10¼-inch) 22-ton guns
Two 21 c/m. (8-inch) 9-ton guns,

besides lighter pieces.

The ships belonging to Groups II. and III. carry

Eighteen 24 c/m. (9½-inch) 15-ton guns
Five 21 c/m. (8-inch) 9-ton guns.

Group IV. carries

Forty 21 c/m. (8-inch) 9-ton guns,

and the armoured gunboats have

Ten 30½ c/m. (12-inch) 35½-ton guns.

The German armoured fleet therefore carries 121 pieces of 9-tons weight and upwards.

Germany: unarmoured ships.

The programme laid down in 1873 allowed for the completion of twenty unarmoured corvettes, six despatch vessels, or fast gun-vessels, and eighteen gunboats. The following are complete or building:—

GROUP I.—Unarmoured cruisers of 3,000 tons displacement and upwards.

Leipzig	Prinz-Adalbert

The 'measured mile' speed of these two ships is sixteen knots.

GROUP II.—Unarmoured cruisers of a displacement between 2,900 and 1,690 tons. These figures are not quite the same as those given in the corresponding division of British ships, which ranged from 2,500 to 1,700 tons. Owing to the different dimensions, the German ships could not be otherwise classified with any approach to accuracy.

(*a*) Sub-class.

Bismarck	Moltke	New Augusta
Blücher	Gneisenau	E. (not named)
Stosch	Stein	F. (do.)
	New Vineta	

These ships, having a speed of fifteen knots, are 500 tons larger than the British C class.

(*b*) and (*c*) Sub-classes.

Freya.

This ship, with a speed of 14½ knots, is of the same size as our 'Amethyst' in (*c*) sub-class of the group.

(*d*) Sub-class.

Augusta	Victoria

These are of somewhat older construction, but are still capable of doing good service.

(*e*) Sub-class.

Luise	Ariadne

The 'Luise' steams fourteen knots, the 'Ariadne' 12·9 knots.

No cruisers exist in the German navy corresponding to the British vessels in Group III.

GROUP IV.—The newer gun-vessels.

Albatross	Nautilus

with a speed of 10½ knots.

Smaller vessels and gunboats are omitted, as also are the still nearly efficient ships of older type, of which the German navy has very few. The unarmoured cruisers of Germany carry twelve 6¾-inch breech-loaders, and 196 six-inch guns, all of Krupp's pattern.

Amongst the armourclads of Italy are several old wooden ships which can no longer be considered thoroughly efficient. The energies of the Italian dockyards have for some years been directed rather to the construction of very powerful iron-hulled vessels than to the repair of obsolete and worn-out wood-built ships. Italy, *matériel*: armoured ships.

GROUP I.—Seagoing ships, and ships which can be employed on foreign service, having not less than 9-inch armour, and carrying guns of not less than 18 tons.

Dandolo	Lepanto Duilio	Italia

The above enormous ships, as it is well known, are to be armed with 100-ton guns.

GROUP II.—Seagoing ships with armour in certain places of seven and eight inches, and guns not inferior to the British 12-ton gun.

Palestro (wood)	Principe-Amadeo (wood).

These were launched in 1872 and 1873. The Italian navy contains no ships corresponding to those placed in Group III.

GROUP IV.—Moderately armoured seagoing ships.

Venezia (wood) Ancona	Castelfidardo Maria-Pia	San Martino

The 'Venezia' was launched in 1871, and carries 10-inch guns, and might almost claim a place in Group II. It is not easy to classify the remaining iron armourclads of Italy, and we shall therefore bring them together.

GROUP VI.—Coast-service vessels of moderate dimensions, armament, and armour.

Varese	Terribile	Formidabile.

The four huge ships in Group I. are to be armed with sixteen 100-ton guns. Armament of Italian ironclads.

Those in Group II. carry

Two 28 c/m. (11-inch) 25-ton guns
Eight 25 c/m. (10-inch) 18-ton guns.

The armament of Group IV. is composed of

Eight 25 c/m. (10-inch) 18-ton guns
Nine 22 c/m. (9-inch) 12-ton guns
Thirty-six 20 c/m. (8-inch) 6½-ton guns.

Nearly all the above are of English construction, made by Sir

Wm. Armstrong and Co., and resemble closely the corresponding Woolwich pieces. Adding for Group VI.—

Twenty (7-inch) $6\frac{1}{2}$-ton guns

it will be seen that the armoured fleet of Italy carries 99 armour-piercing guns.

Italy, unarmoured ships.

The strength of the Italian navy in unarmoured cruisers is not by any means proportioned to the force of armourclads. It is doubtful if any cruiser is really qualified to rank with

GROUP I.—Unarmoured cruisers of a displacement of 3,000 tons and upwards.

Garibaldi.

This ship is of 3,440 tons, but only of 450 nominal horse-power.

GROUP II.—Unarmoured cruisers of a displacement between 2,500 and 1,700 tons.

(*a*) Sub-class.

Cristoforo-Colombo.

This ship has a measured mile speed of $16\frac{1}{5}$ knots.

(*e*) The 'Blanche' sub-class.

Staffetta.

The speed is 15 knots.

GROUP III.—Unarmoured cruisers under 1,600 tons.

Victor-Pisani	Caracciolo	Rapido.

The speed of the 'Rapido' is $12\frac{3}{4}$ knots.

GROUP IV.—The newer gun-vessels:—

Agostino-Barbarigo	Marcantonio-Colonna

These are being built of steel, and are designed to steam seventeen knots an hour. The above ships together carry forty guns of moderate weight.

Austria, *matériel*: armoured ships.

The Austrian Admiralty has devoted great attention to keeping its wooden ironclads in serviceable condition, and has in some cases actually rebuilt them, working—it is understood—much iron into their structures. For this reason the 'Lissa,' though built before 1870, may properly be classed among the effective vessels.

GROUP I.—Seagoing ships, or ships which can be employed on foreign coasts, having 9-inch or thicker armour, and carrying guns not inferior to the British 18-ton gun.

Tegetthoff	Custozza

Group II.—Seagoing ships with armour in parts of seven and eight inches, and guns not inferior to the British 12-ton gun.

Archduke-Albrecht.

The Austrian navy has no ships which can be classed in Group III.

Group IV.—Seagoing ships, moderately armoured, and of comparatively light armament.

Kaiser (wood)	Don Juan	Prinz Eugen
Lissa (do.)	Kaiser Max	

The 'Kaiser' and 'Lissa,' being wooden ships, although protected with 6-inch armour, and armed with 12-ton Armstrong and 14-ton Krupp guns, are scarcely entitled to rank with the heavier ships in this group.

There are no armourclads in the Austrian navy to which a place could be assigned in Groups V. or VI. Indeed, it is doubtful if any can fairly be included in

Group VII.—Small armoured gun-vessels.

Maros	Leitha

These are river monitors for service in the Danube, armed with only 6-inch Wahrendorf guns.

The armourclads of Austria carry the following heavy guns:—

Six 28 c/m. (11-inch) 27-ton guns
Eight 26 c/m. (10-inch) 22-ton guns
Twenty 24 c/m. (9·4-inch) 14½-ton guns
Ten 23 c/m. (9-inch) 12-ton M.-L. guns
Twenty-four 21 c/m. (8¼-inch) 8½-ton guns.

The 12-ton guns are Armstrong muzzle-loaders; the remainder are Krupp's steel breech-loaders. The total armament of the Austrian armoured fleet consists of sixty-eight guns.

Austria: unarmoured ships.

The unarmoured cruisers of the Austrian navy are not numerous.

Group I.—Unarmoured cruisers of 3,000 tons displacement and upwards.

Radetsky	Laudon

Group II.—Unarmoured cruisers of a displacement between 2,500 and 1,700 tons.

(*a*) Sub-class.

Donau	Saïda

(*c*) Sub-class.

Fasana.

(*d*) Sub-class.

Helgoland.

Group III.—Unarmoured cruisers under 1,600 tons displacement.

(*a*) Sub-class.

Zrinyi	Frundsberg	Aurora.

These three, though rather smaller, were launched some years later than our corresponding 'Daphne' class.

Group IV.—The newer gun-vessels.

Zara	Spalato

In addition to the ships already enumerated, the Austrians have a few old gun-vessels still fit for service in the Mediterranean.

Russia, *matériel*: armoured ships.

The Russian fleet is in a condition which renders it extremely difficult to make any satisfactory comparison with the naval forces of other nations. The establishment of the floating *matériel* has been framed upon a principle not observed by other great Powers.[1] The peculiar hydrographical circumstances of the Empire, the older and more settled portions of which have a coast-line only upon inland seas, appear to have led to the adoption of what may be termed a 'defensive' policy of naval architecture. For the most part the long list of armourclads on the Russian Navy List are of the coast-service classes, adapted to the defence of the gulfs and the bays of the Baltic, and the mouths of rivers falling into the Black Sea. The number of armoured ships intended for distant service on the high seas is small; and looking to the date at which they were built it must be presumed that a considerable number can hardly be in efficient condition. It must be kept in mind, therefore, that the ensuing classification has been adopted from considerations of convenience. Absolute accuracy is not attainable with the limited sources of information which are available.

Group I.—Seagoing ships, or ships which can be employed on foreign coasts, having armour of not less than nine inches, and guns not inferior to the British 18-ton gun.

Peter the Great.

This ship is like our 'Devastation,' and, according to certain foreign estimates, is somewhat superior in power.

Group II. has no representative in the Russian service, if we exclude the 'Minin.' The armament falls below that of the standard

[1] Both Sweden and Norway, however, which have separate naval establishments, have confined their armoured shipbuilding to the coast-service classes. This may perhaps be termed the 'Baltic system.'

of this class, and the ship is included in the following group because it is difficult to place her more correctly elsewhere.

GROUP III.—Seagoing ships moderately or partially armoured, with armaments of numerous armour-piercing guns of the lighter natures.

Minin	General-Admiral	Duke of Edinburgh

The 'Minin' is protected over a very limited area with 8-inch armour. The armaments consists of twelve guns, only four of which are of 8-inch calibre. The other ships are the earliest 'belted' cruisers, and were the first representatives of a type improved and made more powerful in the case of our 'Shannon' and 'Northampton.' The Russian belted cruisers are lightly armed.

GROUP IV.—Seagoing ships moderately armoured and of comparatively light armament:—

Knias-Pojarski	Pervenetz Netronz-Menia	Kreml

The 'Knias-Pojarski' has actually made long voyages. The ability of the others to do so may be doubted.

GROUP V.—Coast-service ships with 8-inch and thicker armour, and guns of not less than eighteen tons weight.

Vice-Admiral Popoff	Novgorod

These are the well-known round vessels specially intended for coast defence. They carry guns of heavy calibre.

GROUP VI.—Coast-service vessels of moderate dimensions, armament, and armour:—

Admiral Lazareff	Smertch	Tifon
Admiral Greig	Streletz	Lava
Admiral Tchitchagoff	Jedinrog	Perin
Admiral Spiridoff	Latnik	Wjestchun
Carodyika	Brononnosec	Koldun
Russalka	Uragan	

It would not be safe to attribute to the whole of these seventeen vessels perfect efficiency. They are built of iron, and on the plan of the early American monitors.

GROUP VII.—Small armoured gunboats.

Sistov	Nipopolis

These somewhat resemble the Austrian river monitors, and like them were intended for service on the Danube. They were captured

from the Turks in the late war. It has been reported that they have been given to the Bulgarian authorities.

Russia: unarmoured shipping.

An equal if not greater originality has marked the shipbuilding of Russia, as it concerns her unarmoured fleet. As in the case of the 'Popoffkas' and the 'belted' cruisers so, long ago, in that of her wooden cruisers she followed an architectural line of notable independence, building so-called 'clippers' of a type differing considerably from any found in other European navies. The idea apparently was to provide rapid ships with a few long-range guns, able to make protracted voyages, and prey on an enemy's commerce. This idea has been well followed up of late by the purchase from native companies and from owners and builders in the United States and Germany of fast merchant-steamers of great coal-carrying capacity, as well as by building in the Government dockyards rapid cruisers of the 'Rasboynik' class.

GROUP I.—Unarmoured cruisers of 3,000 tons displacement and upwards.

Rossia	Petersburg	Afrika
Moskwa	Europa	Nishni-Novgorod
	Asia	

All the above are purchased cruisers.

GROUP II.—Unarmoured cruisers of a displacement between 2,500 and 1,700 tons.

(*d*) Sub-class.

Constantine	Vladimir	Vesta

These are purchased cruisers, and are about twenty years old; their efficiency was apparently proved by their services in the late war.

GROUP III.—Unarmoured cruisers under 1,600 tons displacement.

Rasboynik	Kreuger	Strelok
Najezdrick	Djigit	Zabiyaka
	Plastun	

These ships are remarkable for their coal-endurance; they carry sufficient fuel to steam 3,000 miles at nine knots an hour. The armament of the Russian navy is in such a state of transition that, in order to form an estimate of its power, the reader should refer to the special chapter on guns. It is not possible to give anything like an accurate account of the ordnance carried by its ships. The

cruisers in Group III. are armed with three 6-inch breechloading rifled guns made at the Obukoff works on Krupp's plan. The 'Popoffkas' are armed with heavy breechloaders of the same pattern.

United States, *matériel*: armoured ships.

The condition of the United States' fleet is even more peculiar than that of the Russian. It is indeed scarcely possible to classify it in comparison with that of other Powers with anything like even the approximate exactness which it has been attempted to reach in the case of those fleets which have been already reviewed. A recent American authority, writing in June, 1878, describes the condition of the navy in gloomy and desponding terms.

'Nominally our American war-navy contains 117 vessels carrying 1,087 guns; but when we take out the unfinished ships, the ships not worth finishing, the ships unrepaired and not worth repair, and those laid aside as receiving, training, store ships at best, we have already disposed of forty-eight as being no part of the fighting navy. This leaves us but sixty-nine possible war-vessels. Of these two are old sailing vessels of no account; and two dozen more are either building, rebuilding, or repairing—that is, temporarily useless. The net result, therefore, is forty-three war-vessels now available carrying 245 guns, with a total displacement of only 80,665 tons.

'Unhappily we cannot stop even here in our estimate of inefficiency. More than half of all these few remaining ships, viz., twenty-seven out of forty-three, are wooden vessels of the second, third, and fourth rates;[1] and only one-third of these twenty-seven, namely, the "Hartford," "Luckawanna," "Monongabela," "Omalia," "Pensacola," "Plymouth," "Powhatan," "Tennessee," and "Trenton" are of the second rate; the rest are of the third and fourth. Some of these second-rates have fine models and good speed, and could cruise with advantage against the merchant vessels or unarmoured ships of foreign Powers; but the fourteen third rates are all of less than 2,000 tons displacement, except the "Vandalia," which has 2,080, and are of little speed or power. These twenty-seven unarmoured steam-vessels, which are well enough in time of peace, but of so little reliance in time of war, take out no fewer than 52,565 tons displacement and 226 guns from the already scant aggregates representing the efficiency of the American Navy.

'What now is left? We have sixteen war-vessels, fourteen of which are fourth-rate "Monitor" ironclads carrying two guns apiece, ten of them of 1,875 tons displacement and the other four of 2,100. Their total of guns is twenty-eight, and of tons displacement

[1] That is, 'rate' according to the American official nomenclature.

29,775. In addition there are the torpedo-boats "Intrepid" and "Alarm," and such is the effective navy. It is true that the rebuilding of the "Dictator" and the finishing of the "Puritan" would give us a pair of powerful ironclads, the former of 4,500, and the latter of 6,203 tons displacement, but we are talking of what the navy is and not of what it might be; and for the same reason we say nothing of the incomplete "Amphitrite," "Miantonomoh," "Monadnock," and "Terror," each of 3,815 tons.'

That this state of things has not materially changed since the date at which the above description was written will appear from an extract from the report of the Secretary of the Navy, published in December, 1879. A certain amount of repairs had been executed, chiefly upon wooden unarmoured ships. The Secretary says: 'The condition of the navy has greatly improved during the last year. There are now in commission 45 vessels, consisting of cruisers, monitors, and torpedo-boats. Of these different classes, sixteen can be put in condition for sea service in a few months, and twenty could be made ready in an emergency. With this done the fighting force of the navy might be made available in a very short time. And if to this number be added the four monitors, "Terror," "Puritan," "Amphitrite," and "Monadnock," and eight powerful tugs which can be fitted for either cruisers or torpedo-boats, our whole effective fighting force would consist of 93 vessels.'

Admiral Porter, an officer of more than American reputation, says, writing last year: 'Our navy has dwindled away to a trifling number of vessels,' and 'what few ships we have built since the late civil war were of small size and of little importance one way or the other. Most of them would be considered in the British navy as dispatch vessels, forming but a small part of a navy's strength.' Lieutenant Kelly, of the United States Navy, speaks even more strongly of the inefficient condition of the ships of the American fleet, especially of those that are armour-plated. We proceed to give at some length the opinions expressed by persons well qualified to form a correct estimate of the floating *matériel* of the United States. It will be seen that they are agreed that the condition of the fleet is seriously impaired.

Lieutenant Kelly, U.S.N.

Lieutenant Kelly, whom we have quoted, divides the total armoured ships of America into two classes, (1) those for coast-defence, and (2) those for coast and river service. They may be grouped as follows, rejecting those of wood of older date.

Group V.—Coast-service ships.

Roanoke	Oregon	Miantonomoh
Massachusetts	Puritan	Monadnock

All these ships carry smooth-bore guns.

GROUP VI.—Coast and river service vessels.

Ajax	Saugus	Jason
Caucasus	Wyandotte	Lehigh
Mahopac	Carnanche	Montauk
Manhattan	Catskill	Nahant

These also are armed with smooth-bores.

From what has been already said, it will be recognised how difficult it is to classify the unarmoured ships of the American fleet according to the system which has been adopted for the navies of other countries. Practically there are no cruisers of the modern type; but a certain number of the older vessels have been refitted, and are quite capable of being usefully employed during peace. United States: unarmoured ships.

GROUP I.—Unarmoured cruisers of 3,000 tons displacement and upwards.

Trenton.

GROUP II.—Unarmoured cruisers of a displacement between 2,500 and 1,700 tons.

(*a*) Sub-class.

Richmond.

(*b*) Sub-class.

Vandalia.

GROUP III.—Unarmoured ships under 1,600 tons displacement.

(*a*) Wyoming.

The United States Government has a considerable force of wooden unarmoured cruisers, and several have been rebuilt. It may therefore be assumed that the hulls of a certain number are in an efficient condition. It is not likely, however, that these vessels when reconstructed will have a coal-carrying capacity equal to what is now universally held to be necessary to modern cruisers. A few of the American ships are armed with converted rifled guns; the remainder still carry the old smooth-bore.

More complete tables will be found elsewhere, but it may be convenient to insert a compendious summary of the principal navies of the world, dividing the ships into groups, according to the rules of classification laid down in the present chapter. Tabular statement of the navies of the world.

Armoured Ships.

Countries	Seagoing, or suited for operating on Foreign Coasts						Coast Service				
	Group I.	Group II.	Group III.	Group IV.	Total	Heavy rifled guns	Group V.	Group VI.	Group VII.	Total	Heavy rifled guns
France . . .	16	8	1	4	29	157	0	7	4	11	33
Germany . .	9	0	1	3	13	124	0	10	0	10	10
Italy . . .	4	2	0	5	11	79	0	3	0	3	20
Austria . .	2	1	0	5	8	68	0	0	2	2	0
Russia . . .	1	0	3	4	8	? 70	2	17	2	21	? 43
United States .	0	0	0	0	0	0	6	12	0	18	0
Total foreign .	32	11	5	21	69	508	8	49	8	65	106
England . .	20	6	9	5	40	410	8	3	3	14	48

In the 'coast-service' division of the foregoing table perhaps the vessels in Group V. are alone worthy of serious consideration. It should be borne in mind that, though the United States armourclads still carry only smooth-bore guns, their armament might prove formidable to unarmoured, or thinly armoured, antagonists.

Unarmoured Ships.

(Cruisers of the newer types.)

Countries	Group I.	Group II.	Group III.	Total	Older cruisers, perhaps still efficient	Group IV.: the newer gun-vessels
France . .	3	22	21	46	6	3
Germany . .	2	15	0	17	0	2
Italy . .	1	2	3	6	0	2
Austria . .	2	4	3	9	0	2
Russia . .	7[1]	2	7	16	0	0
United States .	? 1	? 2	? 1	4	?	? 0
Total foreign .	16	47	35	98		9
England . .	11	30	24	65		11

England: Government dockyards.

We now turn from the ships of the various navies to the dockyards in which they are constructed and repaired. The naval yards of Great Britain in the United Kingdom are situated at Chatham, Sheerness, Portsmouth, Devonport and Keyham, Pembroke, and Queenstown. Chatham dockyard stands on the right bank of the Medway. The line of wharfage is 10,000 feet, and the embankment 4,500 feet in length. The total area of the dockyard is 500 acres. The older part of the yard, originally founded in the

[1] Purchased cruisers are included in the figures for Russia.

neighbourhood by Queen Elizabeth, has seven slips for building large ships, and three for small vessels, and four dry docks. In 1867 great additions were made to the existing works, and three large basins were formed, communicating with each other, so that ships, by passing through them, can cut off the bend of the river. The repairing basin has an area of 22 acres. It communicates with four dry docks, each capable of receiving a ship of the largest class. The factory basin has twenty acres, and the fitting-out basin 28 acres. The depth of water in all is thirty-three feet at spring, and thirty feet at neap tides. The average number of workmen employed is about 3,500.

Sheerness dockyard is on the island of Sheppey at the mouth of the Medway, and now covers about fifty acres. There are five dry docks for ships of moderate size, and building slips from which of late years several of the larger unarmoured corvettes have been launched.

Portsmouth dockyard has a superficial extent of nearly 300 acres. The older portion of the yard contains two wet docks, the fitting basin and the steam basin, several building slips, and dry docks. In recent years the dockyard has been greatly extended and improved. The old dry docks have been enlarged, and a tidal basin, three floating basins, four dry docks, and a large deep dock have been constructed. The new works are approaching completion. The depth of water is thirty feet at low-water spring tides. The repairing basin covers twenty-two acres, and has a depth of thirty-five feet. The rigging basin and the fitting-out basin each cover fourteen acres. The number of men employed is about 5,000.

Devonport dockyard, which covers ninety-six acres, has several building slips, and four dry docks, of which one is a double dock capable of receiving ships of great length. Keyham dockyard is an adjunct to Devonport, with which it communicates by a tunnel. It has two basins, 630 feet by 560 feet, and 700 by 400 respectively, and three dry docks. The number of workmen is about 4,400.

Pembroke dockyard is on the southern shore of Milford Haven. Operations in this yard are confined to shipbuilding. It covers sixty acres, and has a dry dock and fourteen building slips, six of which are for vessels of large size.

The Haulbowline dockyard, at Queenstown, in Ireland, is still far from complete. It is to have a basin with a depth at high-water spring tides of 32 ft. 8 in. on the sill; and a dry dock 455 feet long with the same depth.

In the colonies we possess several naval yards. At Malta we have two dry docks of great size. At Bermuda we have a floating dock

333 feet long and 83 ft. 9 in. broad on the inside. We have yards without docks at Gibraltar, Halifax, Jamaica, Antigua, the Cape of Good Hope, Trincomalee, and Hong Kong, besides small dépôts for naval stores elsewhere. In Australia, at Hong Kong, and in other colonies, extensive dry docks have been made by private companies, which can be utilised for the repair of ships of the navy. The Admiralty is empowered by Act of Parliament to advance money to the proprietors of docks, on condition that they are constructed of such dimensions that they can receive men-of-war requiring repairs, and that the use of the docks shall be secured to the naval authorities when necessary. Advantage has been taken of the provisions of this Act in certain cases, and Government ships have had access to docks which have been constructed in part by means of the money provided under its sanction.

France: Government dockyards.

In a discussion on the navy estimates in the French chamber in 1878 it was stated that, while England had in her dockyards at home 16,000 workmen, France had 25,000. This large number will, perhaps, explain the rapid progress made in the floating *matériel* of the navy of the latter country.

The following account of the French dockyards is taken from Mr. King's work on the navies of Europe:—

'France is separated into five naval divisions, known as *arrondissements maritimes*, each of which is presided over by a *préfet maritime*. The names of the arrondissements are the same as those of their chief ports: viz., Cherbourg, Brest, L'Orient, Rochefort, and Toulon. Each dockyard is immediately under the command of a rear-admiral, *major-général de la majorité*, who controls the *personnel*. The work in the yard is divided under seven official heads, viz., a major-general, major of the fleet, director of movements in the port, director of naval constructions, director of naval ordnance, naval commissary-general, and medical director. The director of constructions is an officer of the Constructor's Department; he supervises the construction and repair of all ships and vessels and all machinery built or repaired at the dockyard.

Cherbourg.

'The important French dockyard of Cherbourg is but sixty-three miles distant from the Needles, and seventy miles from Portsmouth harbour. In view of the importance of its position in the Channel and near the English coast, the French Government determined, as far back as 1686, to fortify it by a system of forts considered at that day to be impregnable, and to make a suitable *rendezvous* for a fleet and army intended for the invasion of England.

'The dockyard is connected with a spacious roadstead formed by the construction of a grand breakwater, and it is defended by works believed at the time of construction to have been the most successful effort of engineering skill; numerous forts and batteries not only encircle the yard, but also surmount the breakwater; and every other commanding point, both to the seaward and in the rear, has been turned to the best account. The works within the yard and the fortifications without were constructed at an enormous cost and by long and patient labour, having occupied the French fifty-five years, viz. from 1803 until 1858, when the last stone was laid and the late Emperor opened the basin, which then bore his name.

'The breakwater, unquestionably one of the most magnificent in existence, was forty years under construction. Its length is 12,333 feet; at its base its average breadth is about 880 feet, and its height is about 63 feet. To the action of the sea it opposes a wall of dressed masonry, twenty feet in height, carrying a parapet eight feet in thickness and five feet high. Within its vast area it encloses some 2,000 acres of water, affording ample anchorage for all the men-of-war, of all descriptions, which France is ever likely to collect in this quarter. The western entrance is considerably more than two miles wide, while that at the east is about 1,200 yards in width. Through one or the other vessels can either enter or depart in all conditions of weather. The area is about 256 acres.

'The works within the yard consist of three large and two smaller basins, eight dry docks, eleven building slips, and twenty-eight substantial stone buildings. The docks and basins have been excavated from slate-quartz of the same formation as that from which the Keyham docks have been excavated. The first or outer basin, known as the *avant port-militaire*, or Dock Napoleon I., communicates with the roadstead and the other basins. It covers an area of 741,185 square feet. The second or inner basin, known as the *bassin de flôt*, has an area of 686,662 square feet. The third, known as the *arrière bassin de flôt*, or Dock Napoleon III., covers an area of 904,201 square feet. The three basins are connected by locks and gates. Contiguous to the basins are the dry docks; one dock opening into the outer basin, and the remainder into the inner basin.

'Around the basins are distributed the building-slips, workshops, and storehouses. The batteries and walls are constructed with blocks of granite laid in a similar manner to the blocks in the dry docks and the building-slips, and the whole work presents beautiful specimens of masonry.

'The appliances and tools in the workshops are the productions

of Whitworth and Rigby, of England, and of Mazeline and other tool-manufacturers of France. With few exceptions, it may be said that they are of a date anterior to the improved machines in the best English engine-factories. None of the boiler-making tools are of the best varieties, and the shops are deficient in many improved machines found in English dockyards and the best English engine-factories.

'The land approaches of Cherbourg, in addition to the redoubts and forts shown on the plan to which reference has been made, possess features of an interesting kind. An enemy landing near the place for the purpose of its reduction by siege would have no easy task; his every step for miles would be impeded, even by a numerically smaller force, from behind successive natural fieldworks. Cherbourg, when created, was regarded by the first engineers of France as a stronghold, both to seaward and in the rear, frowning defiance to the world; but in those days there were no rifled guns, no heavy ordnance, and none of the destructive projectiles of the present day; nor were there any armoured ships of war. Modern improvements in naval warfare place Cherbourg dockyard, at the present period, in the greatest danger when approached by an enemy from the sea.

Toulon. 'Toulon, in name and tradition, is ranked as one of the most extensive and important dockyards of Europe. Unlike Cherbourg, it is formed on a natural harbour and in a more secure position from bombardment. It is fortified, and the approaches to it are well covered. Its position is naturally strong, standing as it does in the hollow formed by a deep bay, in which are the roadsteads. Behind it, to the northward, rises, tier upon tier, a range of rocky heights, on which, wherever a fort could be erected or a battery posted, guns have been placed in position almost to the summit. These fortifications have been much strengthened since the British possession in 1793. Two small promontories divide the roadsteads, each bearing on its extremity a fort of no mean strength, the cross-fire from which is intended to sink any hostile ship that might attempt to enter.

'The port is familiar to all navigators, and known as one of the best in the world. Entering it from the Mediterranean, an outer roadstead leads by a narrow channel into an inner one of large dimensions. On the shore side of this there is a deep bay, the water front of which is occupied by the dockyard. This bay is about one mile and a quarter across, but, measured by the curve of the shore, the water front is nearly two miles and a quarter, most of which is devoted to Government purposes.

'After passing the Grosse Tour on the right, the first point

reached is the construction yard, where the ship-houses are erected and all the operations of shipbuilding carried on. At a distance of some hundred yards from this is the commencement of the yard proper, which is enclosed by a wall. In front of it, as now completed, there are two large basins, known respectively as the Old and the New Wet Dock. These basins are formed by broad dikes or breakwaters constructed in the water of the bay, on which are erected large shops and storehouses, and the water front on the inside of the breakwater more than doubles the accommodation for vessels which is permitted by the wharves on the front on the main.

'Beyond the precincts of the building now constructed is the Missiessy wet dock, which extends to the left point of the bay in front of the city. It is more commodious than the other basins, the water front on the main being about 203 rods. Adjoining it is the pyrotechnic school, at the village of Brégaillon, on what would be an island but for a narrow isthmus connecting it with the mainland, and immediately south of the Grosse Tour is located the great naval hospital of St. Mandrier.

'The dry docks are seven in number, one of them being in two communicating parts, which, when used as one, admit a length of 500 feet. All are convenient to the Old and the New Basins. The area within the walls is 240 acres.

'The dockyard at Brest is admirably situated for defence, and the magnificent harbour is well protected from the weather. It is only accessible through a single well-fortified and narrow channel, which is about 1,500 feet in length, with an average width of about 525 feet. Both sides of the inlet are devoted to the use of the dockyard, and are lined with quays. Brest.

'The town is situated at the foot and on the slope of a very steep hill; it is divided into the upper and lower towns. So steep are some of the inclines that they are quite impassable except to foot-passengers; the roofs of some houses are almost on a level with the yards of their neighbours. A deep and narrow creek, formed by the mouth of the Penfeld, runs up from the harbour behind the ridge on which the town stands, and forms the basin to the dockyard. The creek on both sides above the castle is enclosed by a high wall, separating the dockyard from the town.

'The area covered by the yard is about 145 acres; on either side is a basin with docks. A third basin, larger than either of the others, is situated at the head of the slip, and has four stone dry docks capable of taking in the largest vessels. The construction of the yard was difficult in consequence of the formation of the land,

which rises almost perpendicularly from the shores of the inlet on which it is located. In order to provide space for the accommodation of the numerous workshops, storehouses, and other buildings required, the land and rock have been terraced, and the buildings on the left side toward the town have been constructed in three ranges, one above the other. The lowest tier is devoted to workshops, storehouses, offices, etc.; the second tier to the *bagne*, formerly used as a prison for convicts, also to the accommodation of a large ropewalk, 1,600 feet in length. On the right side are the works for the construction and repair of steam-machinery, also a barrack for the accommodation of sailors. Its capacity is sufficient for five thousand men.

L'Orient. 'At the northern part of the Bay of Biscay, on the projecting tongue of land between the two rivers, Blavet and Scorff, stands L'Orient, which derived its name from the trade carried on with the East during the past century.

'Its natural advantages have been recognised and turned to account; being well protected from the Atlantic swell by a piece of land to the westward, ten miles in length, on which stands Quiberon, operating as a breakwater, while the isles of Houst, Hoedic, Groix and Belle-Isle to southward also contribute to the same result. It is also tolerably well defended from any hostile approach by the strong fort of Port Louis, the guns of which completely command the entrance to the harbour. The sea defences have been strengthened in the last few years by heavier guns from the Government establishment at Ruelle.

'The importance of L'Orient as a naval, but more especially as a building, station for ships, became acknowledged under the empire of the first Napoleon. The dockyard, which is separated from the town by a lofty wall, comprises about 120 acres. The principal buildings constituting the factory works are on the right bank of the Scorff, and lie between the town and the river; there are, however, several building slips on the left bank, adjoining a small creek to the southward and eastward of the town. Altogether, as a construction yard, its capabilities are large, both for wood and iron shipbuilding; there being two dry docks, one of large dimensions, several building slips, and all the necessary appliances for iron ship construction. It was here that the first two iron armoured ships of France, the "Couronne" and "Héroïne," were built; and several others of late date, including the "Dévastation."

Rochefort. 'At the mouth of the Charente, and about 150 miles south-west of L'Orient, stands Rochefort. It has an excellent and capacious road-

stead, protected by the islands Obéron, Aix, and Ré, and by two strong forts, Boyard and Enet, erected on a sandbank between the two first-named isles.

'The dockyard, which is considered third-rate, was established by the great Colbert; it has since then been augmented from time to time, and now covers about 140 acres within the walls.

'As a construction yard it is well supplied with all the necessary facilities. The ranges of factory buildings and storehouses extend for a considerable distance along the banks of the Charente; and the dry docks, of which there are three, and quite a number of building slips, are conveniently arranged.

'The five national dockyards of France, great as are their capabilities, do not comprise all the establishments for building and repairing ships of war under the orders of the French Government. The shipyards at Bordeaux, at Nantes, at La Seyne, Havre, and other ports, the extensive iron shipbuilding and engineering works and iron and steel manufacturing works at Creuzot (the largest in Europe), and all other works in France, can be placed under the orders of the Minister of Marine on conditions to suit the Government, or men can be conscripted from them into the national dockyards.'

Germany: Government dockyards.

The Government dockyards of Germany are three in number, and are situated at Dantzig and Kiel on the Baltic, and at Wilhelmshaven in the Bay of Jahde, on the North Sea.

Dantzig stands on a river thirty-five miles from the coast. In 1872 the Reichstag voted sums amounting to upwards of 520,000*l.* to strengthen its defences and form a naval yard. The works are not yet completely finished.

Kiel is on the eastern coast of the province of Holstein, and has a large and commodious harbour. Deep water is found so close in shore that the heaviest ships can lie alongside the wharves.

Wilhelmshaven is in the district of Jahde, and was established as a naval port in 1869. The works are on a very extensive scale. The principal basin is 400 yards long and 250 wide. A canal, one side of which is on the foreign territory of the Netherlands, has been constructed to facilitate communication with the port in time of war. Several large ironclads have been built at Wilhelmshaven.

Italy: Government dockyards.

The kingdom of Italy has naval yards at Venice on the Adriatic, at Naples and Castellamare on the Bay of Naples, and at Spezzia between Leghorn and Genoa. The dockyard at Venice comprises

the celebrated arsenal of the days of the Republic. 'The ancient walls,' says Mr. King, 'still remain, also many of the former buildings; but they have been reconstructed to suit the many varied and wonderful changes in naval architecture since the days of the Doges.' The space occupied is about 100 acres. There is one dry dock, and a second is being completed. The Naples yard was formerly a fitting-out station, and that at Castellamare a building establishment of the old navy of the two Sicilies. The latter is not large, but some of the most powerful ironclads in the world, including the 'Italia' launched in the summer of 1880, have been built on its slips.

The greatest naval arsenal of Italy is at Spezzia. Whilst the dominion of the House of Savoy was still limited to the kingdom of Sardinia, Cavour, it is said, had quietly caused the site to be examined with the view of establishing a naval yard which should be worthy of United Italy. Millions have been lavished on the present dockyard, which is becoming one of the most important in the world. Nine slips and ten dry docks were originally contemplated, and two slips and four docks have been already completed. The largest existing dock is 360 feet long. Another dock, 443 feet in length, is in progress. Coaling stations, dépôts of stores, and small yards for the Italian Navy have been established at Cagliari, Genoa, Ancona, Civita Vecchia, Gaëta, Taranto, Palermo, Messina, and Brindisi.

Austria: Government dockyard.

The principal Austrian dockyard is situated at the head of the Gulf of Pola on the Istrian coast of the Adriatic. It was begun in the year 1856. It is composed of two parts, one on the mainland where the workshops and stores are built, and the other on a small island which contains the building and patent slips, and the dry docks. There are three slips. The only dry dock as yet completed is 411 feet long, 82 feet wide at the upper ledge, and 41 feet at the sill. The depth is 28½ feet. A second dock when completed will be of the same dimensions, but will have a depth of 31 feet. The patent slip has arrangements for hauling up four vessels. The number of workmen employed is about 1,500.

Russia: Government dockyards.

The principal dockyards and naval ports of the Empire of Russia are St. Petersburg—an important building yard—Cronstadt, Sweaborg, Helsingfors, and Revel in the Baltic; Nikolayevsk on the Black Sea; and Vladivostock on the coast of the Gulf of Tartary.

Cronstadt is situated on Kotlin (Rat) Island, near the head of the Gulf of Finland, and lies about twenty miles west of St. Petersburg. It is strongly fortified. The fortifications, begun by Peter

the Great, have been strengthened considerably from time to time. The approach from seaward has been secured by sinking ships and filling up some of the channels, and Oranienbaum, on the mainland opposite to Cronstadt, has been strongly fortified. There are three harbours or basins behind the batteries at the western end of the island. The man-of-war basin is capable of containing thirty ships of the largest size. The docks and building slips are extensive. The 'Peter the Great,' turret-ship, was built at this dockyard.

Since the destruction of Sebastopol, the Nikolayevsk yard has acquired considerable importance, and in 1871 it was determined to form an establishment here of the first rank. The yard is divided into three parts. On a level with the town, stands the foundry, which formerly belonged to the artillery. It is capable of casting masses up to a weight of about eight tons. This foundry is continuously employed. Being the only establishment of the kind in that part of Russia, it supplies the wants of the navy and of a large number of private firms. The works on the left bank of the river Ingourn comprise part of the factories, the boathouses, fitters' shops, metal works, a fine covered building slip, and a patent slip for hauling up corvettes. The erection of a large boiler factory was begun in 1876. Here all the boilers for vessels of the Black Sea fleet are in future to be made. There are three building slips, of which one is covered. There are no excavated dry docks, but a large floating dock has been formed, capable of raising the circular ships. The mechanical appliances include both 40-ton and 20-ton shears.

A floating bridge connects this part of the establishment with the works on the other bank of the Ingourn, on which are the inclined planes from which the circular ironclads were launched. Near them is a large space intended for covered building slips; one has been completed some years, and the late Emperor's yacht 'Livadia' was launched from it. The Ingourn has a uniform depth of twenty-four feet. The workshops in this part of the yard are extensive, and furnished with machinery from England; that in the armour-plate factory is of high quality. From three to four thousand workmen are employed in the dockyard. The joiner's work is done to a large extent by contract. Contractors are found at Odessa and even at St. Petersburg, who bring large bodies of workmen to the dockyard and carry out work.[1] This system obviates the necessity of retaining a large body of men when their services are no longer required.

Since the removal of the head-quarters from Nikolayevsk on

[1] *Revue Maritime*, vol. xlviii., 1876; pp. 814–8; from which the above account is taken.

the Amoor river to the south, the chief outlying naval yard is at Vladivostok. The harbour is sheltered from all winds, and can be easily defended. At present there are neither basins nor building slips, but the locality is perfectly fitted for the erection of a good naval establishment. Vladivostok can be defended from an attack by sea by a few batteries and torpedoes. On the land side favourable positions for defensive works can be chosen on the surrounding hills. The bay is frozen over for about two months during the winter.

United States: Government dockyards.

The following account of the dockyards of the United States is taken from Mr. King:—

'The dockyards of the United States are eight in number, and are known as the Portsmouth, Boston, New York, League Island, Washington, Norfolk, Pensacola, and Mare Island navy yards. There are also naval stations at New London, Connecticut, at Key West, Florida, and two others at present unoccupied.

Portsmouth.

'The Portsmouth yard is located at Kittery, Maine, on the river Piscataqua, opposite the town of Portsmouth, N. H., and about three miles from the "bar," or entrance from the sea. The site was purchased June 13, 1800, for the sum of 22,500*l*. It now embraces 164 acres, and is provided with the necessary facilities for building and repairing wooden ships, and with facilities to a limited extent for the repair and refit of steam machinery. There are no permanent stone docks, but facilities are afforded by a floating one of wood. The harbour is not capacious, and the currents are troublesome, but the approaches from the sea to the navy yard afford a mean depth of forty-two feet at low water and 50½ feet at high water. These approaches are defended by Forts McClary and Constitution, —the former designed to mount nine, and the latter forty-six guns.

Boston.

'The Boston navy-yard is in the district of Charlestown, opposite the City of Boston proper, at the junction of the rivers Mystic and Charles. The site was purchased August 30, 1800, for the sum of 32,600*l*. It now embraces within the walls 84 acres, is provided with one stone dry dock, and all the buildings, appliances, and machinery for shipbuilding, marine engine construction, rope-making, and the equipment of vessels. There is also a large area, partly excavated, which can be made available for basin accommodations of large dimensions. The main ship-channel to the fine harbour, between Lovell's and Gallop's Islands, has a depth of 28½ feet at low water and 38½ feet at high water, and the least depth in the channel to reach the yard is 18 feet at low water and 28½ feet at high water.

The defences are Forts Warren and Independence, the former designed to mount 309 guns, and the latter 127 guns. Fort Winthrop, yet to be constructed, was intended to mount 78 guns.

'The New York yard is in the City of Brooklyn, fronting the East River, about 23 miles from the sea. Its site was purchased May 18, 1801, for the sum of 83,000*l*. There is, in all, an area of 193 acres, a portion of which is unoccupied. The yard proper is provided with all the buildings, machinery, and appliances necessary for shipbuilding, including facilities for the construction of steam-machinery. There is one stone dry dock, but no basin, and the wharfage-room is limited to the river front. The noble and capacious harbour, occupied as an anchorage-ground by ships from all nations, is upwards of a mile below the yard, and between seven and eight miles still lower is a second great harbour, sufficient in capacity for the fleets of the world. The main channel for the entrance of ships has a mean depth of 23 feet at low water and 27½ feet at high water. The approaches to New York have been designed to be defended by the following-named forts and guns: Fort Columbus, designed to mount 76 guns; Fort Williams, 78 guns; Fort South Battery, 13 guns; Fort Gibson, 12 guns; Fort Wood, 67 guns; Fort Richmond, 140 guns; Fort Tompkins, 60 guns; Battery Hudson, 50 guns; Battery Morton, 10 guns; Fort Lafayette, 77 guns; Fort Hamilton and redoubt, 88 guns; Fort Schuyler, 245 guns. These forts are not all armed. **New York.**

'The League Island yard is situated on League Island, in the Delaware River, its westerly extremity being nearly opposite the mouth of the Schuylkill River, and extends easterly about two and a quarter miles. The territory was presented to the Government by the City of Philadelphia, August 4, 1868, and embraces the following areas: Area within dikes, 410 acres; area between the banks of the back channel, 305·5 acres; area between the back channel and Government Avenue, that being the northern boundary of the property, 37·25 acres; area outside of dikes to wharf-line, established by City and State authorities as the port-warden's line, beyond which no structures are allowed, 170·25 acres; making, in the aggregate, an area of 923 acres. **League Island.**

'The island is separated from the mainland by a narrow channel known as the back channel, which in former years afforded a passageway for vessels of tolerably large size, but which is now quite shallow, having barely sufficient water for the passage, at the eastern end, of quite small tugboats.

'As yet the facilities for repairing and equipping ships are meagre, there being only three substantial buildings erected. The site has

the advantage of being within easy reach of the iron and coal districts, and far up a river which at the least has 18½ feet of water at low tide and 24½ feet at high tide. The river is defended by Forts Delaware and Miflin, the former designed to mount 156 guns, and the latter 49 guns.

Washington. 'The Washington yard is in the district of Columbia, on a branch of the Potomac River. The site was purchased March 17, 1800, for the sum of 800*l*., and embraces within the walls 42 acres. The yard is used principally for the manufacture of steam-machinery, ordnance, chain cables, anchors, copper-sheathing, etc. Small vessels are, however, occasionally repaired here, and one of the largest frigates was launched from its slip. It is defended by Fort Washington, on the Potomac River, designed to mount 93 guns.

Norfolk. 'The yard generally known as the Norfolk navy-yard, is situated at Gosport, Virginia, on the Elizabeth River, adjoining Portsmouth, and nearly opposite Norfolk. It is near enough to the entrance of Chesapeake Bay to be easily accessible, and at the same time in a position to be readily defended. The site was purchased January 23, 1800, for 4,276*l*. It covers 109 acres, contains one stone dry dock, and is provided with all necessary facilities for wood ship-building, and the manufacture and repair of machinery, and outfits of vessels. Hampton Roads, the outer harbour, is an excellent point of rendezvous for a fleet. The entrance has a depth of thirty feet at low and 32½ feet at high water, and is defended by Forts Monroe and Calhoun, the former designed to mount 307 guns, and the latter 216 guns.

Pensacola. 'The Pensacola yard is on a bay of the same name, in the State of Florida, a few miles from the town of Pensacola. The site was a gift, received March 10, 1828. It contains 83¼ acres, and is provided with facilities for the repair of vessels and machinery. Recently an iron floating dock has been sent there. During the war with Mexico this yard was used as a base of supplies for our blockading fleet; but of recent years it has been used merely as a naval station.

Mare Island. 'The Mare Island yard is the only naval establishment of the United States on the Pacific coast. It is situated in California, near the outlet of Napa Straits, its southern end being opposite the entrance of the Straits of Carquinez, and its westerly shore washed by the waters of San Pablo Bay. The extreme length of this island, including a large tract of tule on the northern side, and extending toward Napa and Sonoma, is about ten miles, and its average width, including tule, about three-quarters of a mile. The area of upland is 741 acres, and of the tule lands on the east side, which will be

available for yard purposes, is 135 acres. The site was purchased January 4, 1853, for the sum of 16,698*l.*, and up to the present time a large amount of money has been spent for buildings and appliances. The work of building a stone dry dock has been commenced. The Mare Island yard is used as a repairing and equipping yard for the Pacific and Asiatic fleets. The excellent harbour of San Francisco, about 23 miles below the yard, has, at its entrance, a mean depth of 25 feet, and is designed to be defended by Fort Point and Alcatraces Island, the former to mount 140 guns, and the latter 94 guns.

'It is proper to remark that the armaments of all the forts named are intended to be changed from light guns to powerful guns, less in number.'

Weapons.

With respect to the weapons with which the fleets of the several Powers already noticed are armed, and the establishments in which they are manufactured, it need only be explained here that they have been fully described in the special chapter on guns. We would however draw attention more particularly to the arrangements for the supply of ordnance to foreign navies. It will be seen that several services receive the more powerful of their weapons from private firms, whose works are in their own or in foreign countries, and that the supply appears only to be limited by the amount of money available to purchase it.

Private industry: mercantile marine.

The possibility of employing vessels belonging to the mercantile marine as auxiliaries to the fleet of a State has already been put to the test. In pursuance of a wise policy the British naval administration has now made arrangements for arming and equipping a certain number of steamers belonging to private owners, and has actually purchased and equipped the 'Hecla,' a steamer originally intended for the Atlantic trade. Russia has also purchased several such vessels at home, and in Germany and the United States. As a matter of fact, it has always been found necessary to reinforce a navy by the ships of the merchant service when an important naval contest has been in progress. In the wars of the French Revolution, Great Britain employed many 'hired armed vessels,' and the United States in the struggle with the Confederates largely increased the Federal navy by the purchase of steamers from ship-owning firms.

Mercantile marine: Great Britain.

In an important lecture delivered at the Royal United Service Institution on March 5, 1880, Sir Donald Currie called attention to the progress of our merchant shipping, and the great comparative increase of the steam tonnage. He said: 'In 1851 we had

3,337,546 tons of sailing ships; in 1878, 4,178,789 tons. But the steam tonnage had increased in a far greater proportion; in 1851 we had 167,378 tons, and in 1878, 2,313,332 tons. It is extremely interesting to look for a moment at the tonnage in the British colonial possessions. In 1851 there were of sailing ships 707,785 tons; in 1878, 1,659,355 tons. The steam tonnage belonging to British possessions in 1851 was 20,233 tons; in 1878 it had increased to 178,995.' There were employed in the foreign trade in 1878 1,820 steam-vessels of a total burthen of 1,811,000 tons; the average, therefore, was about 1,000 tons.

France: mercantile marine.

The total number of ships belonging to the French mercantile marine employed in distant voyages in 1877 was 2,180, with a tonnage of 702,961. The whole number of steamers, in both the home and foreign trade, was 565, the total tonnage being 230,804. In 1878 there were in the merchant service of France only 124 vessels—both sailing and steam—of more than 800 tons. The finest vessels are those of the great companies, such as the Messageries Maritimes and the Compagnie Trans-Atlantique. The French merchant service has been for many years in a languishing condition. An attempt has recently been made to give an impetus to maritime enterprise by means of subventions and bounties on a lavish scale.

Germany: mercantile marine.

The total merchant shipping of Germany at the beginning of 1878 was 4,805 vessels, with a tonnage of 1,117,935. Of these 336 were steamers, with a total tonnage of 183,379, or an average of about 550 tons per vessel. As usual, the more important ocean-going steamers belong to the great companies.

Italy: mercantile marine.

The Italian shipbuilding trade is said to have shared in the general depression of commerce. In 1877 the total tonnage of shipping launched was only one-half the average tonnage built during the ten previous years. Seven-tenths of the total tonnage of the kingdom is launched at Genoa, Savona, and Spezia. On January 1, 1879, there were 10,742 sailing vessels and 151 steamers belonging to the Italian mercantile marine. There were 124 sailing ships over 800 tons, and 16 steamers of between 1,000 and 1,500 tons.

Austria: mercantile marine.

The whole number of vessels of all classes in the Austrian mercantile marine in 1879 was 7,887, with a tonnage of 327,729. The seagoing steamers were limited to the fleet of the Austrian Lloyd Company, which owns 69 steamers averaging 800 tons, mostly built on the Clyde.

Russia: mercantile marine.

During the Russo-Turkish war a large proportion of the merchant steamers were purchased by the Russian Government, and no

authentic returns of the mercantile marine of a date since the war are available. In 1876 the total merchant shipping of the empire was 1,785 sailing vessels, measuring 391,000 tons, and 515 steamers measuring 105,962 tons. The shipping of the Grand-Duchy of Finland was given, at the beginning of 1878, as 1,836 sailing vessels measuring 294,086 tons, and 161 steamers of 8,710 tons.

United States: mercantile marine.

The mercantile marine of the United States in 1878 comprised 3,037 vessels in the foreign trade, of an aggregate burthen of 1,629,047 tons. The steam-vessels were 4,275 in number, a large proportion being employed on inland waters. The most important ocean lines of steamers are those which run from San Francisco to Panama, to China and Japan, and those trading with the West Indies and Central America.

The following table, taken from the author's volume on *Foreign Work and English Wages* (p. 154), gives a general view of the steam shipping of the leading maritime countries. It is extracted from a collection of statistics published by the Bureau Veritas of Paris, showing the aggregate tonnage of the merchant navies of the principal maritime countries for the year 1877-78. River, tug, and purely coasting steamers are not included in this comparison of tonnage.

Steamships	Number	Tonnage
England	3,216	3,465,000
United States	516	609,000
France	275	335,000
Germany	220	254,000
Russia	148	105,000
Italy	92	84,000
Total	5,462	5,595,000

Private industry: Shipbuilding establishments. Great Britain.

It is not necessary to give a detailed account of the several great shipbuilding establishments belonging to private owners on the Clyde, the Mersey, the Thames, the Tyne, and elsewhere, which may be relied on to supplement the royal dockyards in cases of emergency. War ships, both armoured and unarmoured, of the most powerful class have been constructed at these establishments for our own and foreign navies. Turning from the hulls to the engines, it is worthy of remark that the whole machinery of the British navy has been turned out from the private engine-factories of the country.

Compiler at Newcastle.

The following passage from an address on British trade and British workmen, recently delivered by the compiler at Newcastle, embraces

some of the latest statistics bearing on the position of England as a maritime power:—

'If we test our industrial capacity by a comparison with other countries in special branches of enterprise, we shall find much to justify a sanguine estimate of our strength. No instrument of human construction and contrivance represents such a concentration and variety of labour as a ship, and especially a steamship. In no form of enterprise is our ascendency more remarkable than in shipping. In none has our recent progress been more rapid. Our steam tonnage has advanced from 1,212,000 tons in 1870 to 2,949,000 tons in 1880. In the nine years 1870–79, France increased her steam tonnage from 154,000 to 256,000 tons; while in Germany the increase was from 82,000 to 196,000 tons. In both cases subsidies were largely given as an encouragement to timid shipowners. Such is the superior efficiency of steamers, especially in the short trades, that their carrying power is estimated as fivefold that of sailing vessels. Hence it is that Great Britain has acquired a constantly increasing proportion of the trade. According to Mr. Mulhall, we have now 56 per cent. of the carrying power of the world, as compared with 51 per cent. in 1880. In the endeavour to foster their shipping, subsidies and bounties have recently been voted on an unprecedented scale by the French legislature. The premium, authorised by the new law, upon the French merchant shipping is so large that, if it were applied to England, the State would become liable to a payment of 750,000*l.* for the large steamships now in process of building for the Admiralty list. The further payment for distances run might easily reach 15,000*l.* per annum for one of the Atlantic liners, if built in France. More than 1,000,000*l.* has already been paid in subsidies to French shipping. These expenditures are justified on the ground that shipbuilders must be compensated for the duties on raw materials, and shipowners for the losses sustained by the maritime inscription. If the subsidies produce all the effect which those who advocate them anticipate, it is possible that the French people, tolerant as they are of taxation, may at last become impatient under the heavy burden cast upon the many for the benefit of the few. Should such a reaction ensue, precarious indeed will be the situation of the shipowner in France, dependent on subsidies, and ignorant of the economies which those exposed to unrestricted competition are compelled to study.'

France: works of private firms.

While their maritime enterprise is dull and even languishing, in comparison with the vigorous development we have seen in England, some important works exist in foreign countries of which some particulars should be given. Some of these have been resorted to by their

respective Governments for aid in the construction of both ships and machinery, and an account of the more important shipyards may be inserted here. The company known as the *Forges et Chantiers de la Mediterranée* was founded in 1855. Its engine factory is at Menpenti, a suburb of Marseilles. In 1858 the engines of the 'Gloire' were made at these works. The shipbuilding yard is at La Seyne, near Toulon, and here in 1862 the Italian ironclads, 'Maria Pia' and 'San Martino,' were constructed, and some time afterwards the Spanish ship 'Numancia,' of 7,500 tons. The 'Numancia' was the first armoured vessel which circumnavigated the world. The first-class cruiser 'Tourville,' and the powerful armoured ship 'Amiral Duperré,' have been launched from the same yard. In 1872 the Forges et Chantiers Company acquired the works of M. Mazeline at Havre. The number of men employed at the company's establishments on the Mediterranean and at Havre varies from 4,000 to 5,000. M. Normand, of Havre, has also built several unarmoured cruisers of the newer type.

In addition to the naval engine-factory at Indret, where most of the engines for the French ships of war are made, marine steam-engines are manufactured at the great Creuzot iron and steel works, by M. Claparéde at St. Denis, and by other makers.

Germany: works of private firms.

An important iron shipbuilding yard has been established at Stettin, belonging to the Vulcan Company, where several ships have been built for the German Navy. The manufacture of marine steam-engines has become a considerable industry in Germany. At the great works of Mr. Krupp, in Rhenish Prussia, portions of the hulls of large armoured ships and of marine engines are made.

Italy: works of private firms.

The private building yards of Italy are not as yet of much importance. The firm of Orlando Brothers, at Leghorn, seems to be alone capable of turning out large ships. Italy has several establishments capable of constructing powerful marine engines. The National Mechanical Industry Company has works at Naples and at Portici, and employs about a thousand hands.

Austria: works of private firms.

The yards of the two firms known as the Tecnico Triestino and the Navale Adriatico, and the works of the Austrian Lloyd Company are the only important building establishments, in addition to the dockyard at Pola, on which the Austrian Navy can rely for assistance. The Fiume Works, which for some time turned out steam-engines, is now solely employed in the manufacture of Mr. Whitehead's torpedoes. The Austrian Lloyd Company's yard is of considerable size, and admirably arranged. It was established in 1851, and employs about 1,600 men. It has two dry docks and

a large patent slip. The Stabilimento Tecnico Triestino has two factories, one for building ships at San Rocco, and one for the manufacture of engines at San Marco. At San Rocco 600 men are employed, and several ironclads have been built. The engine factory at San Marco has 1,500 hands. At the Navale Adriatico many of the Austrian armourclads were built.

II. *Personnel.*

The object of the present work being the consideration of the *matériel* of the navies of the chief maritime Powers, an examination of the *personnel* of these forces only comes within its scope in a restricted shape. We shall accordingly confine ourselves to a few principal statistics.

Great Britain: *personnel* of the active navy.

On March 8, 1880, in moving the navy estimates in the House of Commons, the First Lord of the Admiralty said that the first vote 'provided for 58,800 men and boys for the service of the navy, including in that number 19,833 blue jackets, 2,300 artificers, 4,800 stokers, 4,500 domestics, including Kroomen, 2,700 boys for service, 2,200 boys for training, and 3,672 coastguard on shore.' In addition to these we had 2,700 officers and men of the Royal Marine Artillery, and 10,300 of the Royal Marine Light Infantry, or a total of 13,000, of whom 6,200 were to serve afloat, and 6,800 ashore. On the active list we had 62 flag officers, 175 captains, 210 commanders, and a number of lieutenants to be gradually increased to 1,000. There are also about 250 sub-lieutenants, 250 midshipmen, and 50 naval cadets serving in the ships of the fleet.

Great Britain: reserves.

On the same occasion the First Lord of the Admiralty stated that 'the Royal Naval Reserve of the first class numbered 12,061, of the second class 5,339, and of the third class, 80, making a total of 17,480; while the Artillery Volunteers numbered 1,109.' The pensioners of the seaman class, including stokers, available for service in the reserve in case of need, numbered 5,890 under fifty, and 5,772 above fifty years of age. Excluding officers exempted from drill on account of age, there are 66 lieutenants, 80 sub-lieutenants, and 130 midshipmen of the Royal Naval Reserve. According to the returns for 1878, the sailing and steam ships belonging to the United Kingdom, engaged in the home and foreign trade, were manned by 195,585 seamen. The crews of the vessels belonging to the British Colonies exceed 40,000.

France: *personnel*, active navy.

The active list of the French Navy includes 50 flag officers, 107 post-captains, 239 commanders, 776 lieutenants, 462 sub-lieutenants and 186 midshipmen, besides 54 engineers of the higher grades. The number of men serving is 35,350; of these 27,200 are aboard ship, and 8,150 at the various head-quarters on shore.

In addition to these there are 12,550 men on permanent furlough (*en congé renouvelable*), and 5,080 in the naval reserve. In 1878 the lists of the maritime inscription contained the names of 161,192 persons, of whom 4,947 were designated 'Captains in the foreign trade.' The members of the maritime inscription were thus distributed:—

In the active service	25,084
In the foreign trade and distant fisheries	21,290
In coasters and 'long-shore craft	31,514
In the minor fisheries	44,018
Unemployed	39,286
Total	161,192

The 35,350 men in the service were thus divided: 1. warrant officers (boatswains, gunners, signalmen, master-at-arms, engineers, carpenters, sailmakers, caulkers), 795; 2. first-class petty officers of all branches, 2,349; 3. second-class petty officers, 4,145; 4. blue jackets and stokers, 21,011; 5. buglers, bandsmen, armourers, yeomen of stores, boys, etc., 7,050.

The French marines are divided into infantry and artillery. They do not, however, in any way form a reserve for the navy, and are never embarked for service. The present corps are not even the official descendants of the old marine regiments, which served afloat in the days of the monarchy of the Bourbons. They were raised especially to garrison the seaports and the colonies, all of which are under the French Admiralty. There are 17,353 non-commissioned officers and men in the infantry, of whom 8,300 are in the colonies and 9,053 are at the seaports in France awaiting their turn of colonial duty. Of the 4,118 marine artillerymen 1,210 are in colonial garrisons, and 2,908 at L'Orient, in readiness to relieve their comrades abroad.

Germany: *personnel*, active navy.

The officers on the active list of the German navy are four flag-officers, twenty post-captains, 45 commanders, 222 lieutenants, 128 sub-lieutenants, and 100 midshipmen and cadets. There are 24 engineers of the higher ranks. The seamen are divided into two divisions, which contain together 79 warrant officers, 738 petty officers, 5,621 'fore-mast men, and four armourers. There is also a division of 400 boys. The marine battalion has 1,178 non-commissioned officers and men. Marines are embarked only in armour-clad ships.

Germany: reserves.

Recruiting for the German navy is arranged on much the same lines as that for the army. Volunteers are accepted, but compulsory enrolment is the chief resource. The liability to serve

extends from the completion of the seventeenth year of age to that of the forty-second. Twelve years must be passed in the fleet or in the See-Wehr. Any youth, whose physical and moral qualities are satisfactory, may volunteer for the navy, on completing his seventeenth year, for a period of either twelve months or three years. The division of boys is intended to train seamen and petty officers for the navy. The duration of the training is three years. Of the twelve years which must be passed in the navy, three are spent in the active service, seven in the reserve, and five in the See-Wehr. There are two lieutenants, 25 sub-lieutenants, and 22 midshipmen in the naval reserve; and 19 lieutenants and 21 sub-lieutenants in the See-Wehr. The torpedo corps of the German navy is distinct from the divisions of seamen. The seafaring population is estimated at about 80,000.

Italy: *personnel*, active navy.

The marines, of which there were two regiments attached to the navy of Italy, have recently been disbanded. The officers on the active list are: 14 flag officers, 36 post-captains, 62 commanders, 201 lieutenants, 150 sub-lieutenants, and 78 senior engineers.

Reserves.

There are 8,544 seamen and petty officers, 2,162 gunners, 846 torpedo-men, and 1,987 artificers and stokers; total 13,539. The system of recruiting is based on that in force in France. The *inscription maritime* contained in 1878 the names of 210,267 persons.

Austria: *personnel*, active navy.

The number of officers on the active list of the Austrian army is so arranged that it may be increased in each grade in time of war. The establishment is as follows:—

	Peace	War
Vice-Admirals	2	3
Rear-Admirals	6	7
Post-Captains	16	22
Commanders	19	21
Lieut.-Commanders	22	25
Lieutenants	150	219
Sub-Lieutenants	155	216
Cadets	163	244

The complements of all the fighting ships of the navy if complete would amount to 9,895 officers and men. The number of seamen actually employed in peace-time is 5,771.

Reserves.

The navy is recruited partly by a general levy from the seafaring population of the Empire, and partly by voluntary enlistment. The term of service is eight years. The merchant seamen and fishermen are 28,752 in number.

Russia: *personnel*, active navy.

In the Russian navy there are 89 flag-officers, 650 captains, commanders and lieutenant-commanders, 656 lieutenants, sub-lieutenants and midshipmen, 528 navigating officers, and 563 engineers.

The total number of seamen is 24,500, of whom a large proportion are ashore in barracks and serving in the Black Sea, Caspian, and Sea of Aral squadrons. The whole length of service in the navy is fixed at ten years, viz., seven in the fleet and three in the reserve. Reserves. Service is compulsory, as in the army, but a large number of men is obtained by voluntary enlistment from the Grand Duchy of Finland. The seafaring population of the latter province alone, not counting the fishermen, amount to 10,000.

The officers on the active list of the United States navy are: United States: *personnel*, active navy. 13 flag-officers, 25 commodores, 50 captains, 90 commanders, 80 lieutenant commanders, 280 lieutenants, 100 masters, 100 ensigns, and 53 midshipmen serving afloat. There is one battalion of marines, and the crews of the ships in commission amount to 7,500 men. No reserve has been organised. The total, including retired officers and marines, is 11,500.

CHAPTER V.

UNARMOURED SHIPS.

SECTION I.

Moderate Dimensions.[1]

THE duties and services which vessels of war are required to perform are so various in their nature, that it is altogether impossible that the same classes of ships can be advantageously employed, both in line of battle and for the police of the seas. In the present chapter it is proposed to consider what types are best adapted for the protection of commerce, and for maintaining our communications in time of war. These are duties for which speed, both under sail and steam, and seaworthiness under every condition of weather,—in short, all the qualities which tend to make a ship ubiquitous—are essential.

Unarmoured ships indispensable.

The construction of an armoured fleet does not make unarmoured ships the less necessary. The House of Commons was cautioned by Lord Clarence Paget, in moving the Navy Estimates in 1864, that 'it would be a mere deception of the public to pretend that the increase of the armour-plated vessels would lead to any diminution in the number of unarmoured ships. We are not prepared as yet to throw off armour from our first-class vessels of war. Our unprotected vessels are required for the police of the seas, and the protection of commerce.' The same observation is equally true in 1881.

Assuming, therefore, that a due proportion of unarmoured ships is essential to the efficiency of the navy, it is important to consider what types or classes of ships are the best adapted to protect our commerce, to keep open our communications with foreign settlements, and to convoy the supplies of food from abroad, which are indispensably necessary to the sustenance of our population. For such a service we do not want large and costly ships. The class of vessels required as the skirmishers and sentries of the line-of-battle

Unarmoured ships should be reasonable as to cost.

[1] This section is founded on the pamphlet published by the compiler in 1875.

ships, to do for the fleet what the cavalry does for an army, requires more consideration than has yet been given to the subject. The sailing fleets of olden times were attended by a numerous flotilla of corvettes, brigs, gunboats, and cutters. In the present day the screw ship of the line has acquired the same mobility as the smallest and lightest vessel; but, just as in military operations on land, a whole battalion should not be told off to take the post of a sentry, nor a regiment of cavalry to escort a solitary staff officer, nor 130 pieces of cannon to convoy a letter, so it would be culpable waste of power to employ powerful and costly ships in services of secondary importance.

For a blockade numerous ships essential.

The experience of the war against the Confederates in America has shown that, when a blockade is to be maintained on a long line of coast, or where the navy is called upon to pursue privateers or cruisers, few perhaps in number, but roaming at large over the ocean, individual power will not compensate for insufficiency of numbers. In January, 1865, 671 ships were in commission in the United States Navy, the greater number being employed in blockading the coasts of the Southern States. Doubtless the blockade might have been more strictly maintained by a smaller number of more efficient ships. But the most powerful vessel can only be at one place at one time, and that, as Admiral Scott most truly says, is just the place that a wary adversary would avoid.

Large American frigates.

While the French have reluctantly followed us in the construction of large and costly cruisers, the United States have, in former days, been eager and successful rivals in the speed, dimensions, and armament of their cruising ships. In 1855 they made a great stride in advance by building the 'Colorado,' and the 'Merrimac,' ships of 4,600 tons, which, however, failed to attain a speed of more than 9·5 knots. The 'Niagara,' from the designs of the celebrated shipbuilder, George Steers, came next. The dimensions were increased in this case to 5,475 tons, and the maximum speed attained was twelve knots.

'Orlando,' 'Mersey,' 'Galatea.'

The English Admiralty followed in the same line by building the 'Immortalité,' 'Orlando,' 'Mersey,' 'Ariadne,' and 'Galatea,'—vessels, in their day, without a rival in any European navy. The great advance in the size of the modern frigates is sufficiently proved by the fact that the 'Emerald,' though of moderate dimensions, when compared with several frigates built in the later days of wooden ships, was a ship of 2,913 (O.M.) tons, or thirty-one tons larger than Nelson's famous three-decker, the 'Victory.' The 'Emerald' attained a speed of thirteen knots.

Fast American cruisers.

During the war with the Secessionists, some fast corvettes were ordered for the United States Navy, the Confederate cruisers, though inferior in armament, having been found superior in speed to the ships of the United States Navy. In order to obtain higher speeds, vessels of 3,200 tons were laid down. Of these the 'Guerrière' steamed twelve knots, but the 'Idaho' was a failure, and the result in the case of the 'Wampanoag' must be hereafter described from American sources.

Proceedings of English Admiralty.

Meanwhile, the English Admiralty had become disquieted by the reports which had been circulated of the speed and power of the new American corvettes, and in 1865 they proposed to build seven ships of the 'Inconstant' class, of 5,328 tons, combining full sail-power with a speed of sixteen knots under steam. The armament consisted of ten 12½-ton 9-inch rifled guns on the main deck, and four 6½-ton 7-inch guns on the upper deck.

French swift cruisers.

In France some vessels were proposed for a similar service, but of much more moderate dimensions. The 'Château Renaud,' of 1,900 tons displacement, and a speed of fourteen knots, is an example of the type adopted.

'Wampanoag,' U.S.N.

The event proved that our naval administrators had been most unnecessarily alarmed by the reports they had received of the anticipated performances of the new American corvettes. It was stated in the Report of the Board of Steam Machinery Afloat for 1869 that the cost of the 'Wampanoag' was 63,000*l.*; that she could carry only 750 tons of coal, of which 200 tons were stowed on the berth deck; and that this supply was barely enough for four days' steaming at full speed. Owing to the acute shape of these vessels, not a single gun could be used on the gun deck, in giving chase to an enemy ahead, and even the use of the stern guns was essentially hampered by want of room. They declared that no wooden vessel of war of such great length and small proportionate depth, however well put together, could endure rough seas, without evincing a palpable want of longitudinal rigidity. They complained also of the slowness in turning. The engines and coal represented 84 per cent. of all the weight the hull could accommodate below the water-line, leaving only sixteen per cent. for masts, sails, cables, ordnance, and provisions. They said that the 'Wampanoag' had undoubtedly proved very fast. For twenty-four consecutive hours the average speed was 16·95 knots, while the maximum speed was 17¾ knots; but at this extreme rate the consumption of coal was 175 tons a day, and the coal-endurance was sufficient for only 950 miles. 'The weight of her battery was insignificant.' 'Her accommodation for her crew was strikingly con-

fined. Looking upon her as a whole, it seemed impossible to resist the conclusion that she was a sad and signal failure.' The Americans finally decided on making considerable reductions in the engine power of this class. Four boilers were removed, and these vessels can now steam at the rate of ten knots an hour. The critics of British naval administration may derive some consolation from this short history of an American failure.

H.M.S. 'Inconstant.'

We now return to the ships which we had built in England as an answer to the 'Wampanoag.' The 'Inconstant,' when tried at sea, proved a marked success, in steadiness of platform, speed under steam, economy of fuel, handiness, good sailing qualities, safety and comfort in a gale of wind, and power of armament. She showed a great superiority in sailing over the armoured ships of all classes, including the partially armoured 'Warrior,' whose good qualities as a sailing vessel were well known. The 'Inconstant' was therefore a successful vessel as a rival to the 'Wampanoag,' but the type was ill adapted to the protection of our commerce. The reason was explained to the Committee on Designs. Captain Waddilove, who had lately commanded the 'Inconstant,' was asked by Captain Hood the following question:—'Looking solely to the protection of our commerce, and seeing that the "Inconstant" of 4,066 tons, O.M., steams 16½ knots at the measured mile, and the "Volage" of 2,300 tons (O.M.), steams 15¼ knots, would it be more advisable to have a certain number of "Inconstants" or double the number of "Volages"?' He answered, 'If you are to capture privateers of great speed, you must have something that will equal or surpass them in speed. I think that double the number of "Volages" would be a better provision for the protection of our commerce than half the number of "Inconstants."' 'Do you think that a vessel of 2,300 tons possessing the power of steaming fifteen knots has ample speed for the protection of our commerce?' To this question the answer was, 'I should think she probably has; but if the enemy's vessels were faster than that, of course it would be insufficient.'

Captain Waddilove, R.N. 'Inconstant' too large for protection of commerce.

Sir E. J. Reed, M.P.

Sir E. J. Reed, the designer of the 'Inconstant' under instructions from the Board of Admiralty, vindicated the principles embodied in this ship with his usual ability. He considered that the moral power of the country would be better sustained in war time by a more limited number of extremely fast ships. He thought that our commerce should be protected by vessels both of the 'Inconstant' and the 'Volage' classes, and that the 'Volage' might meet with vessels which could get away from her, and that such an occurrence would have a demoralising effect. The 'Inconstant' was built, as he

'Inconstant' built as an answer to the 'Wampanoag.'

elsewhere argues, not from any conviction of an abstract nature, as to the superiority of the design over others which might have been produced. She was designed 'of her size, of her cost, of her length, of her horse-power, and with her armament and speed, expressly to compete with, and worthily to compete with, a very powerful class of American vessels, which were then under course of construction. There was a large number of very powerful and fast vessels indeed building in the American Navy. They were not successful; in the main, they were very unsuccessful, although some of them met with a fair measure of success: but we could not afford in this country to wait and see whether they were to be successful or not; we had to produce a ship which would compete with them, and the very best possible reason for laying down any ship was the existence of ships in other navies that we wanted to compete with and be superior to.'

Admiral Scott and Sir E. Reed.

The 'Inconstant' found another powerful defender in Admiral Scott. He maintained that it would be a fallacy to suppose that our cruisers could be small vessels; because small vessels could not possibly possess coal-carrying power. The argument of Admiral Scott would, however, tend to show that the large steamers of the mercantile marine, which carry coal sufficient for a voyage from the United Kingdom to Australia at full speed, have a marked superiority over the 'Inconstant,' which would exhaust her supply of coal in two and a quarter days, and which, even at the comparatively slow speed of ten knots, could only carry coal for a distance of 2,160 miles, or about two-thirds of the distance from Liverpool to New York. The 'Inconstant' could never venture to use her extreme speed when cruising in search of an enemy. Her speed would be about the same, and her powers of ranging over the ocean would not exceed those of the 'Volage;' and if the extreme speed of the 'Volage' had been as great as that of the 'Inconstant,' it is obvious that the protection of our commerce would be twice as effective, if we had double the number of ships. These views of the present writer were long since given to the public. They are confirmed by the higher professional authority of Captain Long, R.N., in his essay, read before the United Service Institution on the tactical power of the merchant ship. Reviewing the general policy of unarmoured construction, he is of opinion that a vessel of the displacement of Her Majesty's ship 'Volage' combines power and efficiency, without representing too large a fraction of the total force, and that all despatch vessels could be procured from the mercantile marine.

Captain Long, R.N.

In several able papers Mr. Barnaby has brought prominently into notice the rapid growth of expenditure on the larger unarmoured

ships lately added to the navy. The original cost of the 'Inconstant' was 214,000*l.* The 'Raleigh' cost 193,000*l.*, the 'Shah' 234,000*l.* The 'Inconstant,' which is the most powerful of all, has but one sister, the 'Shah.' The proportionate cost of the latest cruisers would be about as follows:—'Rover,' 40; 'Bacchante,' 44; 'Raleigh,' 50; and 'Shah,' 60. In order of displacement they stand:—'Rover,' 3,500; 'Boadicea,' 4,000; 'Raleigh,' 4,700; 'Shah,' 5,400.

Arguments for moderate dimensions.

Mr. Barnaby, I.N.A., March 26, 1874.

In the actual state of naval power abroad the most serviceable vessel for the protection of commerce would seem to be a ship not exceeding in any case the dimensions of the 'Volage'; though some vessels of that class might possibly be made more efficient for service in European waters, or even in the North Atlantic, if their spars were reduced, and their steam-power and coal-carrying capacity, and perhaps their armament, were proportionately increased.

The designers of the largest vessels enumerated were betrayed into an exaggeration of size from over-anxiety to combine in a single ship every quality with which an unarmoured vessel can possibly be endowed. The 'Inconstant' was to possess unrivalled speed both under sail and under steam, and was to be armed with such a powerful battery of armour-piercing guns that it was hoped an engagement might be fought even against an armoured ship with some prospect of success. The attempt was ambitious, and led to the production of a ship confessedly too costly for the mere protection of commerce. 'A perfect ship of war,' as it was prudently observed by the Admiralty Committee on Designs, 'is a desideratum which has never yet been attained, and is now further than ever removed from our reach.' Any near approach to perfection in the one direction inevitably brings with it disadvantages in the other. In the case of the 'Inconstant,' the cost was such as to make it impossible to multiply vessels of her type in sufficient numbers for the protection of the valuable and scattered commerce carried on in every sea under the British flag.

The French have not been more successful than the English constructors in the endeavour to combine heavy guns, large sails, and great engine-power in an unarmoured ship. Referring to the 'Tourville,' Mr. King says:—'The French naval authorities, in building this, their first rapid cruiser, have, in many features of the hull, followed the system of the English, and have accepted the errors admitted by the British authorities to exist in their modern frigate, the "Shah." Besides the original great cost, large cost for mainte-

'Tourville,' Mr. King, U.S.N.

nance, and unwieldy bulk to handle, the motive power is decidedly objectionable, and the coal-supply is only 655 tons.

Debate in House of Commons, 1866.

The 'Inconstant' was not very far advanced when the current of opinion began to set in the opposite direction. In the debate on the Navy Estimates of 1866, Mr. Hanbury Tracy said there was a prevalent impression throughout the Navy that fast seagoing cruisers and despatch-boats were what we wanted for the safety of our commerce. The cruising vessels should be able to go thirteen to fourteen knots, while the despatch vessels should have a speed of from fifteen to sixteen knots. In the same debate Mr. Graves said that we wanted swift handy vessels of moderate size, capable of remaining at sea twelve months under canvas, and steaming at a high rate of speed on an emergency.

Mr. Graves.

A second 'Inconstant' had been provided for in the programme of 1867–68, but Mr. Corry, on succeeding as First Lord, resolved instead to build a smaller corvette, the 'Volage.' Mr. Corry, as we are told by Sir Spencer Robinson, believed that this ship might be multiplied without extravagant cost, while her speed of 15·128 knots on a six hours' trial trip was then rightly regarded as ample for every purpose. Mr. Childers in 1869, and Mr. Goschen in 1872, both expressed an opinion adverse to the construction of the very costly unarmoured vessels of the 'Inconstant' and 'Bacchante' class, and in favour of ships of the dimensions of the 'Druid' or the 'Amethyst,' as the most useful vessels they had at that time.

Report of Committee on Designs.

The Committee on Designs, while expressing their belief that the 'Inconstant' class was calculated to perform very valuable service, suggested a subdivision, the one class to possess the sail-power of the 'Inconstant,' whilst the other might have increased speed, say eighteen knots at the measured mile, with a considerably reduced spread of canvas, and a larger supply of coal. The former class would be the more useful in distant seas, the latter would be the more valuable nearer home.

After a long interval the 'Iris' and 'Mercury' have been built, and a new class of steam cruisers has now been designed in conformity with the suggestion of a separate type, more lightly rigged, and more powerfully engined.

The final performance of the 'Iris' of 17·97 knots at the measured mile entitles this ship to the place of honour as the fastest seagoing steamship in any navy. This high speed is, however, attained by an immense expenditure of power. As Mr. King remarks, in his volume on European ships of war, the engine-power of the 'Iris' is considerably more than was ever previously put into a

naval hull of the same dimensions, and it will remain to be proved by practical trial at sea whether the hull is of sufficient strength to sustain for a lengthened time the immense strain of 7,000 horse-power. That power, however, as Mr. Barnaby points out, is in two separate engines, with two propellers.

Comparative cost per ton of 'Iris' and 'Inflexible.'

The really serious objection to the 'Iris' rests on financial grounds. She is far the most costly unarmoured ship, in proportion to her tonnage, which has ever been constructed. The returns to January 1, 1879, show the cost of the machinery alone to have been 102,000*l.*, the cost of the hull 106,736*l.* The displacement of the 'Iris' is 3,735 tons, and the cost when completed for sea may be roughly estimated at 58*l.* per ton. In round figures the 'Iris' is as costly per ton as the 'Inflexible.' The great ironclad presents the utmost possible combination of fighting power. The unarmoured 'Iris' can have no pretensions to enter the line of battle.

As examples of naval architecture, Mr. King awards the highest praise to the 'Mercury' and 'Iris':—'They are the first of a new type designed for high speed as the pre-eminent requisite. All other requirements are to be subordinated to this important element. The model from which they are being built presents a beautifully sharp bow, a long, exceptionally clean run, and altogether an admirable specimen of a design for a swift and lightly-sparred vessel.'

It will not be necessary to carry further these criticisms on individual ships. Let us therefore turn to the opinions of authorities, naval and professional, on the general policy of shipbuilding in the unarmoured classes. Captain Noel, the author of *The Naval Prize Essay for* 1876, advises that a limit should be put to the number of ships of above 2,500 tons, and that those below that tonnage should be increased. His proposal for a fleet of cruisers includes six protected cruisers of the first class of 5,000 tons, with a speed of fifteen knots, twelve of the second class of 3,800 tons, twelve of the third class of 2,500 tons, twenty-four of the fourth class of 1,800 tons as the most useful class for service on foreign stations, and special unarmoured cruisers of great speed, in such numbers as may be required.

Captain Noel, R.N.

Lieutenant Eardley-Wilmot.

Lieutenant Eardley-Wilmot, the author of another essay, highly approved by the Council of the United Service Institution, remarks that 'ten corvettes of the "Gem" class would cost but little more than four of the "Iris" type, and would prove far more effective for the general purpose of defending commerce.'

M. Dislère.

Passing on to the most recent expressions of foreign professional

opinion on this subject, we find the same principles advocated by M. Dislère in *La Marine Croisière*. 'The displacement must be limited, both because it is desirable to avoid building unhandy ships, and because it is necessary to distribute the strength of the navy, so that all its resources may not be concentrated in a few hulls, exposed, the large not less than the small, to the various dangers of navigation and naval combat. We must therefore give a due proportion to the various elements which combine to make the cruiser the distant representative of the national power. No one of these elements must be sacrificed to another, which the fashion of the day represents as of primary necessity, such, for example, as armour-protection or extreme speed.'

M. Dislère suggests that 'the most serviceable cruisers would be vessels armed with two or four 64-pounder guns, with as many guns in addition, of a smaller calibre, as it would be possible to place on the upper deck. The maximum speed would be fifteen knots. The displacement should certainly not exceed 2,900 tons. The loss of a ship of that size would not be a catastrophe so grave as the loss of a vessel like the "Inconstant" or "Duquesne," costing a quarter of a million sterling; and the services performed, so long as the cruisers were restricted within their appropriate sphere, would be much the same, whether the vessel were a small corvette or a large frigate of extreme speed.' The French constructors are of opinion that the cruising ship should have a displacement of from 3,000 to 3,200 tons, with a moderate length, high freeboard, and a speed of sixteen knots.

Admiral Touchard.

The best type of cruiser, according to Admiral Touchard, should be a wooden ship of greater speed than the majority of the foreign ironclads, more handy under canvas, and costing one third or one fourth of the price of the larger ship. That is to say, for the cost of an ironclad cruiser with a covered battery, you would have three or four wooden ships, their guns mounted *en barbette*, of higher speed and far better adapted than any ironclad for long and distant cruises in time of war. The Germans, it may be remarked in passing, have not attempted to introduce vessels of the 'Raleigh' type into their navy.

The German Navy.

Admiral Porter, U.S.N.

From the United States we have the high authority of Admiral Porter, as an advocate of small ships for the protection of commerce. In his report of 1871–72, after calling attention to the progress of the principal navies of Europe, he proposed to take steps to make good the great deficiency of the United States Navy in cruising vessels, by building twelve wooden vessels of not over 1,000 tons

each, and six or eight similar ships of iron, fine sailing models with a full spread of canvas, good steam-power, and lifting propellers.

For a cruiser of the first class, Mr. King recommends a much larger type. Referring to Her Majesty's ship 'Rover,' he says:— 'The displacement of this vessel is 3,494 tons. She was made large enough to be seagoing, to act as a ram, and to be fast; and no ship having structural strength to withstand the engine-power necessary to drive her fifteen knots per hour, to act as a ram, to have all the requirements necessary for a war-ship, and to keep the sea as a cruiser, is likely to be made very much smaller until some further advancement is made in engineering.'

The most recently constructed cruiser in the United States Navy is of a larger class than that recommended by Admiral Porter, but still falling far short of the dimensions of our largest unarmoured ships. The 'Trenton,' of 3,700 tons displacement, has a speed of thirteen knots, and especially deserves the attention of our constructors from the height at which she carries her guns, her main deck being 7 ft. 6 in. above the water. She has a spar deck, and is a most seaworthy vessel. In comparing the 'Trenton' with the 'Comus,' the points of inferiority in the American ship are that she is built of timber throughout, and has no protection for the engines by coal-bunkers or other means. The other principal data are given by Mr. Barnaby in the following table:— 'Trenton,' U.S.N.

	Comus[1]	Trenton
Relative size	24	37
" engine-power	23	31
" sail-power	77	99
Weight of armament	16	28
Number of guns in broadside	8	6
Complement	245	450
Speed (full bunkers)	$12\frac{3}{4}$	$12\frac{3}{4}$
Coal-supply	370	316

The expression 'belted cruiser' will have been noticed in the extract from Captain Noel's prize essay. The writer remarks on the temerity of Admiral De Horsey in engaging the 'Huascar' in the unarmoured 'Shah.' The encounter between the 'Shah' and her antagonist affords an illustration of the weakness of the largest and costliest unarmoured vessels. It has been acknowledged by all competent authorities that the 'Shah' was not an equal match for the Peruvian ironclad. But the 'Shah' cost nearly a quarter of a million when finally equipped for sea, or much more than double the cost of the 'Huascar,' and she was manned by a crew of 600 men, All large cruisers should have a belt of armour. 'Shah' and 'Huascar.'

[1] With steel underwater deck.

while the complement of the 'Huascar' was less than two hundred. The 'Shah' is unnecessarily large for the destruction of commerce, and she was a weak antagonist for a small armoured ship. The fighting power of the 'Shah' mainly consisted in her numerous crew. It would therefore have been more judicious to rely on superiority of *matériel*, on thicker armour and heavier guns, rather than on a superiority in the force of seamen, which it is difficult to retain in distant waters. As compared with the 'Huascar,' the 'Shah' was necessarily inferior for the use of the ram. The 'Shah' was 300 feet in length. The length of her antagonist did not exceed 200 feet. The 'Shah' was at a disadvantage from her draught of water, which was 27 feet, while that of the 'Huascar' was only 14 feet. The ineffective fire from the light guns of the 'Shah' against the thin armour of the 'Huascar' confirms the views so often expressed by Sir E. J. Reed, who has consistently maintained that unarmoured vessels of great size and cost should carry an armour-piercing armament.

Every ship which is specially constructed for naval warfare should be protected by a certain amount of armour. A large array of professional opinion can be brought forward in support of this proposition. Captain Noel urges that a fractional part of the displacement should be reserved in every vessel for the light armour, with which the vital parts should be protected. He further recommends that the belt of armour-plating at the water-line should be supplemented by coal-bunkers, properly fitted for the stowage of coal.

Captain Noel.

Commander J. B. Haye, R.N.

In an essay highly commended by the United Service Institution, Commander J. B. Haye expresses his opinion as follows:—

'Protected cruisers will certainly be necessary in the North Atlantic and Mediterranean, and perhaps one or two will be required for other stations.

'The protected cruiser should carry a few heavy guns amidships on the main deck, behind armour of at least sufficient thickness to keep out common shell, with heavy bursting charges, the remainder of the armour being placed so as to defend the vital parts alone, viz., steering gear, engines, crowns, and up-takes of the boilers, magazines, and shell-rooms. The water-line should only be protected in the wake of these vital parts, the floating power of the ship being attained, as far as possible, by multiplying the watertight compartments, every advantage being taken of the best material, to ensure strength combined with lightness.'

Lieutenant Eardley-Wilmot does not admit that any unarmoured vessel can be an efficient fighting ship, even if carrying heavy guns,

and he recites his experience of the sailing capacity of the 'Triumph,' which had traversed 30,000 miles in the Pacific during one commission under sail alone. Lieutenant Eardley-Wilmot, R.N.

Admiral Scott concurs in the views expressed by the younger officers, and is of opinion that all large vessels should be lightly armoured. 'The few single ship actions of late years have been practically decided by a single shot, as in the case of the "Schwartzenberg" (really a single ship action), the "Alabama," and the "Bouvet." It is therefore essential that the structure be so arranged that no single shot, and consequently not several different shots with mere local effect, should destroy the ship, or even permanently put her out of action. Yet most of the unarmoured classes, except perhaps the very latest, are liable to be destroyed or have their boilers or machinery damaged by a shot of no very great size. It is a poor return for a great coal-capacity or great speed to have to expose bunkers when emptied to the chance of being filled with enough water to sink or waterlog the vessel, or engines to damage, and the ship to foundering in consequence of a single injury by shot, ram, or torpedo. Several of the unarmoured classes have one bulkhead right forward, introduced after the loss of the "Amazon," and have shown that many excellent qualities were not very useful in a ship that trifling damage could send to the bottom. Several others have only that partition and one other before the main mast.' Admiral Scott.

The encounter between Her Majesty's ships 'Shah' and 'Amethyst' and the Peruvian ironclad 'Huascar,' is full of interest in relation to the question of retaining armour for the protection of ships of war. The results of the combat are, it is obvious, decidedly in favour of the retention of armour. Though the 'Huascar' was struck a hundred times, only one 9-inch shot penetrated three inches into the turret, and that without doing any material damage. The engagement was fought at distances varying from 200 to 3,000 yards, and lasted three hours. As the plates of the 'Huascar' were but 4½ inches in thickness, the armour would easily have been penetrated by the 'Shah's' 9-inch and 7-inch guns, provided that the shot had struck at right angles. The experiences of the action show how rarely in practice this is likely to occur, and how immensely the power of destruction is reduced when the armour is struck obliquely.

The importance of armour-protection even in so-called unarmoured ships has been more and more recognised in later designs. The following observations are from the *Standard* of September 25, 1879: —'The under-water shot-proof deck is a most valuable innovation on the original mode of protecting the vessel against the enemy's *Standard.*

fire. From the corvette class upwards, nothing is now being built for the British Navy which is not, in a certain sense, "protected." Thus the ship which is considered to be unarmoured, because she is not an ironclad, yet has her boiler and engines placed under cover of an armoured deck below the water-line.'

Power of cruising under sail. Vessels of the 'Alabama' class, capable of keeping the sea for a lengthened period, and never using coal except when actually chasing an enemy, are essential to our fleet. The 'Alabama' was 214 feet by 32 feet, drew 15 feet, carried 300 tons of coal and six months' stores. The engines were of 300 horse-power; the tonnage was 1,044 tons; the cost, 47,500*l.*, or 45*l.* a ton. Such vessels, it is not necessary to say, should be able to use their canvas with effect. Officers who have served in the 17-gun sloops of the 'Rinaldo' class will realise with regret how much has been sacrificed in modern ships in order to add to the armament and diminish the draught of water.

General conclusions. Summing up the various opinions which have been quoted with reference to the dimensions of unarmoured cruisers, we find the late Mr. Graves recommending vessels of the 'Albama' class of 1,000 tons. Admiral Porter in his report of 1872 adopted the same tonnage. Vessels of this class with a good spread of canvas are essential for the police of the seas in those remote parts of the ocean in which it is necessary that our flag should be seen, and that our power should sometimes make itself felt. They might be substituted for the schooners now employed in the Australian station with much advantage, not merely for the performance of the service for which they were primarily designed, but also for the training of the navy.

For the first-class cruiser, the dimensions were reduced by Mr. Corry from the 5,328 tons of the 'Inconstant,' to the 3,060 tons of the 'Volage,' the speed falling off from 16·5 to 15 knots. The cost was reduced from 215,000*l.* to 126,000*l.* Mr. Childers in 1869 and Mr. Goschen in 1872 pointed to the 'Druid' of 1,755 tons, and the 'Amethyst' of 1,978 tons, as most useful vessels for the police of the seas and the protection of commerce. Even for a first-class cruiser, M. Dislère and the French constructors generally are unwilling to go beyond a limit of size ranging from 2,200 to 3,200 tons. The tonnage of the 'Trenton,' the latest large cruiser built for the United States Navy, is 2,300 tons. Mr. Barnaby has been an earnest and convincing advocate of moderate dimensions for unarmoured ships.

Advantage of numbers. Amid many conflicting opinions there is perhaps only one essential point, as to which unanimity prevails in regard to our ship-building policy. By universal consent, an advantage in point of numbers is of the last importance for the defence of our wide-spread depen-

dencies, and all will agree with the Committee on Designs that 'In every description of unarmoured ships the smallest dimensions, consistent with the attainment of the requisite speed, should be adopted.'

We require for cruising purposes, for showing the British flag in foreign ports in time of peace, and for protecting our commerce in time of war, vessels of the 'Alabama' class, or of the far more formidable 'Comus' type. It is admitted that the smaller cruisers must succumb to larger vessels in an engagement, but it does not follow that the smaller classes are incapable of doing effective service. The prospect of meeting a 'Raleigh' or an 'Inconstant' is remote. A ship of small size may have fully repaid her cost, by the destruction inflicted on an enemy's commerce, before she meets with an adversary of overwhelming power. We shall require another class of cruisers of the same tonnage as the 'Comus,' but with lighter spars, and a speed of not less than sixteen knots. Both classes are now being added to the Navy. 'Comus.'

CHAPTER V.—(*Continued*).

UNARMOURED SHIPS.

SECTION II.

Paper read at the Institute of Naval Architects, Session of 1876.

THE questions discussed in the preceding pages have long engaged the attention of the compiler. In 1876, at the seventeenth session of the Institute of Naval Architects, he was requested to read a paper on the subject. The paper, with the discussion which followed, is inserted here, in further elucidation of the views entertained by the writer.

General principles of ship-building policy.

'It is as a Member of Parliament, deeply interested in the Navy, and not as a naval architect, that I have been invited to read a Paper before this Institute; and it is from an administrative and not from a constructor's point of view that I shall endeavour to treat my subject. I shall accordingly break ground by laying down certain axioms, which, however familiar they may be, cannot be too constantly present to the minds of those who have to control or criticise the management of the Navy:—(1) There must be a limit to expenditure. Even when the nation may be anxious to vote lavish sums for the Navy, a wise statesman will deem it to be his duty to keep in check the impulses of patriotism; for he knows full well that a prodigal outlay on our part will probably arouse the jealousy of foreign Powers, and lead to a proportionate expenditure on their own armaments. (2) The expenditure on naval construction should be devoted mainly to ships intended for the line-of-battle. The type will vary with the progress and the modifications of naval warfare; but, whatever the type may be, it is to the production of the most powerful fighting vessels that the resources of the Navy should be principally directed. We are not prepared as yet to throw off armour from our first-class vessels of war. Unprotected vessels, therefore, are of subordinate importance. They are required for the police of the seas, and the protection of commerce; but I should consider it unwise on the part of the Admiralty to build a greater number of

vessels of this class than are absolutely necessary in order to meet the demands of the Foreign Office for protection to British interests abroad. There must, of course, be enough vessels to furnish reliefs for ships coming home from foreign stations. Further than this we need not go in the construction of unarmoured vessels.

Treaty of Paris.

'Before entering upon the special subject before me, I should like to advert briefly to another question—one of the highest importance—not, perhaps, suited for full discussion on this occasion, but which has, nevertheless, a direct bearing on our policy in relation to the construction of unarmoured vessels. By the Treaty of Paris, England and France have entered into a solemn contract with the maritime world to respect private property, not being contraband of war, if carried in ships bearing the neutral flag. Is it to our interest to seek to abrogate the treaty into which we have entered? Our maritime trade being infinitely more extensive than that of any other nation, the area of vulnerability which we expose to attack is infinitely larger than theirs. On the other hand, our superiority in actual preparation for war to any probable, I might almost say possible, combination of nations against us is incontestable; while our unrivalled resources for the construction of the most powerful ships would give us the means of adding to our existing fleet with a rapidity which could not be equalled abroad. If, therefore, any future naval contest in which we may be involved is confined to the fighting ships on either side, and to naval operations directed against fortified places, we shall be the greatest gainers by the adoption of the new rule of international law. If these anticipations are correct, the necessity for the construction of the costly ships of the "Bacchante" type disappears, and we can devote to the building of fighting ships the money we have hitherto expended on unarmoured vessels. The large amount of that expenditure is the least satisfactory feature in our naval estimates, because, costly as they are, we are told by high authorities that we may not reckon upon our unarmoured ships as forming an essential part of our armed strength for war.

Resources in merchant navy.

'These considerations point to the policy of maintaining the smallest possible unarmoured navy consistently with its efficiency for the police of the seas. For the training of seamen, for the purpose of exhibiting the British flag in foreign ports, and especially in the harbours of semi-barbarous Powers, who can scarcely realise the existence of a force unless it is visibly present to their gaze, for the repression of piracy and slavery, and for the punishment of offending savage tribes—we want, not "Inconstants" nor "Opals," but the infinitely cheaper little vessels of the "Mallard" class. It is

further to be observed that we possess, in the overwhelming superiority of our merchant navy in powerful ocean steamers, resources which are practically inexhaustible for the equipment of a fleet of unarmoured cruisers. This is another reason against a larger expenditure on unarmoured ships than the public service for the time being absolutely requires. The programme of shipbuilding proposed for the financial year 1876–77 seems wisely conceived with reference to all these various considerations. There will thus be added to the navy in 1876–77, 23,762 tons, of which 11,393 tons will be armoured, and 12,369 tons unarmoured vessels.

'While there is no great difference in the tonnage of the armoured and unarmoured ships to be built for the year, it is unnecessary to remind a professional audience that the number of tons affords no indication of the relative amounts to be expended on the two classes. The armoured ships will of course absorb a far larger sum than the unarmoured vessels.

Committee on designs. 'I observe with satisfaction that the programme of the Admiralty includes no ship so large as the "Inconstant." The designers of that vessel were betrayed into an exaggeration of size from over-anxiety to combine in a single ship every quality with which an unarmoured vessel can possibly be endowed. The "Inconstant" was to possess unrivalled speed, both under sail and under steam, and was to be armed with such a powerful battery of armour-piercing guns, that it was hoped that an engagement might be fought, even against an armoured ship, with some prospect of success. The attempt was ambitious, and not altogether unsuccessful; but the "Inconstant" must be admitted to be too costly a ship for the mere protection of commerce. "A perfect ship of war," as it was very prudently observed by the Admiralty Committee on Designs, "is a desideratum which has never yet been attained, and is now further than ever removed from our reach." Any near approach to perfection in the one direction inevitably brings with it disadvantages in the other. In the case of the "Inconstant," the cost was such as to make it impossible to multiply vessels of the type in sufficient numbers for the protection of the great commerce which is carried on in every sea under the British flag.

Programme of Admiralty. 'The latest programme of the Admiralty shows that these considerations have been duly appreciated. The largest vessels now being constructed are the "Euryalus," the "Boadicea," and "Bacchante," of 16 guns, 3,932 tons displacement, 700 nominal, or 5,250 indicated, horse-power, and costing in round figures 200,000*l.* The cost of this class shows a small reduction upon the price of the "Inconstant";

and the vessels of more recent design exhibit a still more marked recognition on the part of the Admiralty of the necessity of keeping the cost and dimensions of unarmoured ships within reasonable limits. The measured mile speed of the vessels of the "Opal" class is estimated at thirteen knots. They are armed with 64-pounder guns, and can carry coal enough to steam 2,680 miles at ten knots, or 4,050 miles at eight knots. The French ships of the "Infernet" type of 1,890 tons displacement, as compared with the 1,864 tons of the "Opal," can steam, it is said, 4,000 miles at 10 knots.

'Great Eastern.'

'Vast tonnage is not necessary in order to obtain high speed. The experience gained in the unfortunate example of the "Great Eastern" is conclusive on this point. Within certain limits, there is considerable economy in increasing the length of ships constructed to carry cargoes; but the same considerations do not apply in the case of ships of war. Cruisers for the protection of commerce would rarely be required to exert the full power of their engines, except in action, or in pursuit of an enemy. They would traverse the ocean and keep their station under sail, or, if under steam, they would proceed at the most economical rate of speed. By increasing the dimensions, a better result may be obtained for mercantile purposes with a given consumption of fuel; but economy of fuel is less important in a vessel of war, and multiplication of numbers is an important element of strength and efficiency. Recent experiments by Mr. Froude tend to prove that the dimensions of ships may be considerably reduced without loss of speed, and justify the view expressed by the Committee on Designs, that in every description of unarmoured vessel the smallest dimensions consistently with the attainment of the required speed should be adopted.

Mr. Froude's experiments.

'Iris' and 'Mercury.'

'For European waters a large spread of canvas is not required. Hence a subdivision of the unarmoured class, as proposed by the committee, would appear advisable, the one class being furnished with a considerable spread of canvas, while the other might be lightly sparred, and have sufficient engine-power to attain a speed of eighteen knots at the measured mile. The design for the "Opal" class seems to accord satisfactorily with the suggestions of the committee as to vessels intended to cruise principally under sail, and the new despatch vessels, "Iris" and "Mercury," now being constructed at Pembroke, would seem to be a satisfactory class of swift and lightly-sparred vessels for the protection of commerce. The "Iris" and the "Mercury" have a displacement of 3,693 tons, and they are to be propelled by engines of 7,000 indicated horse-power. They will steam at the rate of 17½ knots, or twenty statute miles, an hour, and

their coal-carrying capacity will be sufficient to enable them to steam 6,200 miles at the rate of ten knots, and 8,600 miles at eight knots an hour. In the French vessels of the corresponding class it is proposed that the coal-supply should be sufficient for steaming 5,000 knots at a ten-knot speed. The limited supply of coal is a most serious defect in English vessels of the older types.

'It has already been pointed out that the small unarmoured vessels are growing more and more into favour with the Admiralty. The "Coquette" class has been highly approved in America. They draw ten feet, are 125 feet in length, and are of composite construction. Their coal-supply is sufficient for a voyage of 1,440 miles at eight knots an hour.

'Having now completed the enumeration of the unarmoured vessels in actual progress for the fleet, it affords me much satisfaction to be able to say that I believe the policy of the Admiralty in regard to shipbuilding has been devised by wise counsellors—men of rare experience, whether as sea officers or as naval architects—of whose talents the country has just reason to feel proud, and whose proposals deserve the support and the confidence of Parliament. The amount of expenditure proposed for the Navy must at all times afford more or less occasion for debate, and the subject will undoubtedly be discussed with anxiety in the House of Commons; but, as to the types—and this is what we have chiefly to consider at the Institute of Naval Architects—I venture to affirm that the recent course of the Admiralty, in the adoption of more moderate dimensions for the unarmoured fleet, merits our hearty approval.'

The compiler's paper gave rise to a discussion. The principal speeches were reported as follows:—

Sir Frederick Grey.

The Hon. Sir FREDERICK W. GREY, G.C.B., Admiral: I do not rise for the purpose of making any remark on the different types of unarmoured vessels to which Mr. Brassey alluded at the end of his paper, but I wish to call attention to the administrative part of it. Mr. Brassey, in the beginning of his paper, said that there were two axioms which ought always to be present to our minds, and one was that there must be a limit to expenditure. That, I think, we all agreed to; but the question comes, what is that limit? What would have been a very wise limit in the year 1830 would be an unwise limit in 1876; therefore it is impossible, I think, to lay down any strict rule upon that point. But that is not the point. The point to which I wish to call the attention of the meeting is the second head: 'The expenditure on naval construction should be devoted mainly to ships intended for the line of battle. The type will vary with the progress and the modifications of naval warfare; but, whatever the type may be, it is to the production of

the most powerful fighting vessels that the resources of the Navy should be principally directed. We are not prepared as yet to throw off armour from our first-class vessels of war. Unprotected vessels, therefore, are of subordinate importance; they are required for the police of the seas and the protection of commerce; but I should consider it unwise on the part of the Admiralty to build a greater number of vessels of this class than are absolutely necessary in order to meet the demands of the Foreign Office for protection to British interests abroad. There must, of course, be enough vessels to furnish reliefs for ships coming home from foreign stations. Further than this we need not go in the construction of unarmoured vessels.' Now it is to this that I take exception. I maintain that that is not the rule that should govern our policy with reference to the construction of unarmoured vessels. It is, I think, undoubtedly our duty to keep up in peace time a sufficient force to enable us at the commencement of a war to put forth our strength in a way worthy of the country. Our standing Navy should be the nucleus of the larger force required in war. Whatever our reserves may be—and I am afraid they are at this moment very far short of what we should wish them to be—their efficiency in a war will depend upon the efficiency of our standing Navy with which they will be incorporated; that Navy now comprises only about 18,000 continuous service blue-jackets, and yet small as that force is you have not cruisers enough to give them the practice afloat necessary to keep them efficient. Therefore I contend that there is a great fallacy in Mr. Brassey's paper on that point, and when he tells you that you may limit the number of your unarmoured vessels to the number required for the protection of your interests, I think he makes a great mistake. I think that we ought to have a sufficient number of small cruisers and unarmoured vessels on all our stations to give full employment to our men, and particularly to the young lads on whom we spend so much money in training them for the Navy. We know at present that there are large numbers of these lads idling away their time in home ports. The First Lord of the Admiralty has told us that he has not enough unarmoured ships to meet the demands for reliefs abroad. We have not the means of giving employment to young captains and young commanders that we ought to have, and, therefore, in every way it is evident that our unarmoured fleet now at sea is insufficient for the purposes required. It is on that point that I differ from Mr. Brassey. This is no new opinion of my own. When I was taking part in the administration of the Navy at the Admiralty twelve years ago, I brought the question seriously before my Chief, and pointed out that unless we did take measures to increase the number of our unarmoured ships and cruisers, we should be driven to the necessity of repairing old worn-out vessels in order to meet the demands of the day, and I appeal to our President to say whether that did not really happen, and was constantly happening for many years? I therefore maintain that Mr. Brassey is in error when he tells us that we can limit our unarmoured ships to the number required for the police of the seas. I have made these few remarks because, thinking the subject so very important, I did not like to pass it over.

Captain Scott, R.N.

Captain Scott, R.N.: I should like to make one or two observations, because it seems to me that Mr. Brassey, although he has done good service to us in calling attention to our Navy and mercantile marine, starts with a fallacy. That fallacy is, that we may remain as we are until war actually breaks out, and then, by means of our merchant navy and other means, be enabled to cope with any combination of Powers. The great point to this country is to preserve its trade; if we interfere with its trade, we at once cut off the sinews of war. Therefore, I maintain that what we have to do is to preserve our merchant vessels, and to keep them running just as they are in time of peace, in order that our food supplies and our communications with our Colonies, which are so important, be not interrupted. I may say, moreover, that, with regard to our merchant navy, I think the course that has been taken in drilling these men as reserves is admirable; but the reserve men must remain in their own vessels and young captains must command their own ships. In time of war these vessels should be ready certainly with the torpedo and light guns, to resist any privateers that might attack them. I gather, however, from Mr. Brassey's paper, that, in the opinion of the most eminent Frenchmen, they would leave our Navy alone, and would attack our merchant vessels. Our merchant vessels must be carrying in time of war munitions of war as well as food supplies, so that nearly every vessel would be liable to seizure. Of what use is speed unless, when the vessel is carried to the point she wishes to arrive at, she is able to fight? - I think it is a fallacy to suppose that our cruisers are to be small vessels. A small vessel cannot possibly have coal-carrying power, which is the backbone of the whole matter. She cannot be a ram, which I hold that all these cruisers should be, and which our constructors are now making them; and she cannot carry the heavy guns which will enable her to compete with any vessel that may come against her. I think, therefore, there is a great fallacy in what Mr. Brassey says with regard to the tonnage of our vessels. I do not concur in his views of the great advantage of small tonnage.

. . . .

What is the use of speed, as I have said, unless you have coal-carrying power to maintain it? You are governed by the coal-carrying power; and, therefore, it would be a great fallacy to build these small vessels that Mr. Brassey, I think, mainly advocates.

. . . .

Another point is, that our vessels are spread over the globe. Looking at the fact that they will be attacked by the navies of other Powers, which will endeavour to cut off our lines of communication, it becomes a question not only whether our cruisers should carry heavy guns, but whether they should not, like some of the cruisers now being built, be belted cruisers. I believe myself that is the direction we ought to take, and that with a number of belted cruisers, carrying heavy guns, we should be at all times ready to withstand all the vessels of the world. I did not wish to speak on Mr. Barnaby's paper, which requires very great consideration, though it is alluded to, and in a measure really bears

on the present one, as to vessels to act as auxiliaries and supports to the armourclads. In my opinion, certainly every armourclad, if not every ship of war, should have a proper combination of the gun, the ram, and the torpedo, and sufficient small guns to keep off any attack of lighter vessels. I think without such a combination no vessel of war can be considered perfect, and I think, moreover, that you require, if you have groups of squadrons, somewhat equal coal-carrying power, or means of coaling at sea, which we have not yet hit upon. In conclusion I think that the vessels the Admiralty are now building, such as the belted cruiser, are the vessels required for our needs at the present moment, and which will enable us to maintain that supremacy which we have always held on the ocean.

Mr. E. J. REED, C.B., M.P.: It is so great a pleasure to have the advantage of Mr. Brassey's views in this Institution, that I, for one, feel disposed to take all that he says in the best possible part, because I am quite sure he not only brings a very cultured and thoughtful mind, but a very zealous one, with regard to the interests of the naval service, to bear on these questions. But I wish to say a few words on this paper; and, in the first place, I want to defend what I consider to be one of the finest ships in the world from unmerited depreciation on the part of Mr. Brassey; I refer to the 'Inconstant' frigate. Mr. Brassey says of that frigate, that she 'was to possess unrivalled speed, both under sail and under steam, and was to be armed with such a powerful battery of armour-piercing guns, that it was hoped an engagement might be fought, even against an armoured ship, with some prospect of success.' I should like just to correct that statement to this degree, to say that she was intended to possess unrivalled speed under steam and to have a fair spread of canvas; but so far as I ever heard—and I was the principal designer of the vessel, under the guidance of distinguished officers who are here, and I am able to speak confidently on the point—there was no ambition whatever to obtain any excessive speed under sail, or to enter into any competition with other vessels under sail. With regard to the other point, about the armament, I wish to say that she had an armament of 12½-ton guns given to her. When Mr. Brassey says that the attempt made in this ship's design was ambitious, and not altogether unsuccessful, I beg leave to state that that is not doing full justice to the 'Inconstant.' I wish to say that the 'Inconstant' fulfilled actually, and more than fulfilled every object set before the designer of her in the preparation of the design; and I do not believe there is a single ship in the British Navy of which I have heard higher praise, for enormous speed under steam, for wonderful steadiness of gun-platform, and for the due performance of all the duties that she was intended to fulfil. But I wish to say another thing about the 'Inconstant,' and it is, that the 'Inconstant' was not constructed without a very sufficient reason for her existence. It is very well for my friend Mr. Barnaby to give us general suggestions in his paper, and most valuable; it is very well for Mr. Brassey to give us the benefit of his present cogitations on the subject; but there is one consideration superior to, and

Sir E. J. Reed, K.C.B.

which always must and will outweigh the abstract thoughts of any of us, and that is the state of foreign navies; and I say that the 'Inconstant' was designed—of her size, of her cost, of her length, of her horse-power, and with her armament and speed—expressly to compete with (and worthily to compete with) a very powerful class of American vessels, which was then under course of construction. There was a large number of very powerful and fast vessels indeed building in the American Navy. They were not successful—in the main they were very unsuccessful—although some of them met with a fair measure of success; but we could not afford, in this country, to wait and see whether they were to be successful or not; we had to produce a ship which would compete with them; and I say that that fact affords the very best possible reason that you could have for laying down any ship—namely, the existence of ships in other navies that we wanted to compete with and be superior to. Now there was a remark, which this paper raises, which fell from our President, and I am very glad to have the opportunity of the incidental corroboration of the view which I am going to express which his speech furnishes. He

Armament. spoke of unarmoured but heavily armed ships. Now I wish to say that unarmoured but heavily armed ships have been abolished in the British Navy, except in the case of the 'Inconstant' and one or two vessels. The gunnery advisers of the Admiralty have persuaded them into believing, what I believe to be a most fatal error, namely, that unarmoured ships should not carry powerful guns, but are better armed when they carry a large number of weak and inefficient guns. I have before stated the fact that I believe that to amount to an absolute blight fallen on the naval power of this country. I quite admit that, for some purposes, the 64-pounder guns which are being put into our ships are valuable; but I say I view with the greatest possible alarm the fact that my honourable friend is able to state to this Institution—I do not know whether he did give the statement—that we are building ships to go 17½ knots an hour, with steel hulls and great coal-carrying power, and we are going to mutilate those vessels by putting into them nothing but 64-pounder guns. I know that, in making these observations, I have to work up against the opinion of some naval officers of considerable eminence; but I believe myself, the very advantage, the very superiority which we ought to secure for our ships of the Royal Navy, as compared with merchant vessels, is that our ships should be made fit to carry, and should carry powerful guns; while we know that unarmoured ships of the merchant navy should be made only to carry the lightest guns, in the event of their being required.

Coal-supply. I wish I could hope that anything said here would induce the Admiralty to reconsider their decision on that point, because I consider that that is one of the most fatal errors that has ever befallen a Navy like ours. Mr. Brassey says, in his paper, that the coal-supply was inadequate in ships until a recent date.

Mr. Brassey: The French claimed greater coal-carrying capacities for their vessels than we have given to ours until lately. Whether they were justified in that I do not know.

Mr. REED: I do not believe in what the French claim, because I find, in matters of speed, coal-carrying power, and other things, the French claim not only what is difficult but what is impossible, and I am sorry to say, I am incredulous as to the impossible. But I do wish to point out that the coal-supply question has been for very many years under the most careful consideration at the Admiralty, and we have had for a long time vessels in which large coal-supplies form a very considerable item. Just to give an instance, take the case of the 'Volage.' She has been at sea now for two or three commissions. That vessel carries such a large supply of coal, and is so efficient in other ways, that she was actually made to tow up the Indian Ocean two steam frigates, whose coal it was desirable to economise. We all know, also, that in the 'Devastation' we gave an enormous coal-supply as soon as we did away with masts, and we have received information that during the passage of His Royal Highness the Prince of Wales down the Red Sea, the other day, on his return from India, the 'Raleigh,' a ship which has been occasionally brought under some imputations, distinguished herself by her enormous speed, and by the fact of her coal-supply holding out far beyond that of the vessels with which she was in company. I say that these indications given by vessels, some of them a long time at sea, are extremely satisfactory. Now, on the general question, I wish only to add one remark. Sir Frederick Grey has spoken strongly in opposition to Mr. Brassey's view, and Captain Scott has practically done the same with regard to the limitation of the number of unarmoured ships. I want to say in support of Mr. Brassey, and in support of any views, however mistaken, that we may hold upon this question, that we are in a very unfortunate position—I am speaking on behalf of the British public—from never being told what these unarmoured ships are wanted for, in anything like detail. No information of that kind is ever put before Parliament or the country. This year, at a time when great pressure is being put on the country in order to build a quantity of additional unarmoured ships, we are still entirely without information as to what uses these ships are put to on foreign stations. I have not the smallest doubt that they are to be used for the best purposes, but we do not know. We can take up the 'Navy List,' and see where they are, but that is all the information vouchsafed to us with regard to their employment. If some one of the gentlemen here, who are in the highest degree competent to give us that information, would tell us what are the demands made by the requirements of the service on the Navy for unarmoured vessels, they would greatly help us out of our present difficulty. Mr. Brassey's paper is an extremely interesting, valuable, and suggestive one, but I think he will find that Captain Scott is right in saying that if you will have very small vessels you must have very inefficient ones. I go with Mr. Brassey to this extent, and I go with him gladly, that we are now in a better position than ever we have been in before for producing small vessels with high speed and good coal-carrying powers. Great improvements have taken place in materials, and ideas are changing very much, and I think that the Admiralty have shown us that a great progress may be made in that way; and if it were not for the wretched

Foreign squadrons.

armament of the 'Iris' and 'Mercury,' I should say that in those vessels they have put before the world a type of ship of the most extraordinary character, and possessing immense speed, and every qualification that can be required on the part of very fast unarmoured vessels.

Mr. William Denny.

Mr. WILLIAM DENNY: Allow me to say a few words on Mr. Brassey's suggestions with regard to the employment of merchant steamers for war purposes. Although I am not fitted to speak on war vessels generally, yet I feel myself thoroughly well fitted to speak on this point: and I think that if the country trusts to the fast and speedy vessels of the merchant service for doing war service, they will trust to a broken reed, because I do not think it is within the power of those vessels to do it. They have great speed and great weight-carrying powers, but they are, every one of them—at least the best of them that are being built at this present moment—built to the very narrowest margin of stability; and I am perfectly certain that every person who knows the merchant service, and the large merchant steamers of the Cunard, the Peninsular and Oriental, the Royal Mail and other companies, knows the fact that they are built with just the least possible margin of stability. Now on this account heavy guns cannot be carried in a fast merchant vessel even of a large size, because if they are carried these merchant vessels will simply capsize. I do not wish to enter into a general discussion, but I have thought it my duty to direct attention to an inaccuracy of statement by which the country might be deceived with regard to large merchant vessels. They are undoubtedly fine vessels, but they are built for a purpose, and that does not include a large margin of stability.

The Earl of Lauderdale.

The Right Hon. EARL OF LAUDERDALE, K.C.B., Admiral: With reference to Mr. Brassey's paper, it is my belief in case of war what we require is a great number of unarmoured vessels to protect our trade. We should require thousands of them. Comparatively speaking, the whole seas are covered with our merchant ships, and without we have plenty of these unarmoured vessels, there would be the endless expense of building these large ironclads to look after our trade. The House of Commons, I think, would never find the money. The question is whether we are to build a number of unarmoured vessels at present to protect our trade. People say we ought always to be ready with large vessels in a fleet for fighting men of war, but if we go to the great expense of building vessels that will protect our trade, they must be fast vessels, and by the time they are wanted they will be out of date. You will find the merchant vessels protecting themselves. In former times all the trade was protected by men-of-war; they had no protection, they had no speed; but now it is just the reverse; the fast vessels that would take care of themselves are nine-tenths of them merchant vessels, and my idea of our policy is simply this: when a war is declared, we have nothing to do but to go into the market and hire all the fast merchant vessels, of which a great number would be thrown out of employ, and then they would protect their own trade. It is like the vessels that we made letters of marque in the late war, and privateers. You have only to hire these vessels, and my belief is, instead of building an enormous navy of unarmoured vessels to protect our trade, that

that would be much the quickest and the cheapest way of doing it. Of course if there was a war merchant vessels would have to go in batches under convoy; they would not cover all the seas, but they would have to collect together from the different parts of the world and be convoyed by men-of-war. My opinion is you would in the simplest way possible by that means get the means of protection for them ready-made to your hand. I believe one of the greatest questions of the present day is, how are you to get men to man them when you want a number of these vessels, because the men will not come to the Navy now, and boys will not come; they would rather go to the merchant ships, because they give them better pay. That will be a very great difficulty before long.[1]

Sir R. Spencer Robinson, K.C.B., F.R.S., Admiral: There is one observation I should like to make, which perhaps would be better made before the House of Commons than here; still I should wish to make it. Mr. Brassey, in the very interesting and able paper which he read to us, refers to the Treaty of Paris, and Captain Scott in dealing with the question had evidently the Treaty of Paris in his mind. I want to say a word upon that. The Treaty of Paris, as you know, makes enemies' goods safe under a neutral bottom, and it has been thought by many that a neutral bottom covering enemies' goods in this way procured to this country an immense advantage. It is quite clear *primâ facie* it may be so, because the goods you want to send all over the world, on which our commerce depends, might be, if not contraband of war, carried safely in neutral bottoms, and it might be, although I know very well that there would be considerable difficulties, that the whole of the British merchant ships might find it desirable to put themselves under foreign flags, and carry on their commerce as they did before. I refer to this because Mr. Brassey, in his able paper, mentioned this as one of the reasons for not keeping up a large force of unarmoured vessels. As I think with Sir Frederick Grey, Captain Scott and others, that a large force of unarmoured ships of war is at any rate essential for the due supremacy of this country on the seas, I wish to point out one objection to the view that Mr. Brassey has taken of the effect of the Treaty of Paris on our merchant shipping. You must remember that contraband of war in the neutral vessel will not be safe, and therefore all our supplies of provisions will be liable to capture. As to coal, it is not yet a decided question, but whether it is contraband of war or not it would be made so without any doubt whatever. Coal, therefore, provisions, gunpowder, torpedoes, and anything which could be utilised for the equipment of a fighting ship would all be contraband of war, and we could not supply our distant regions with the facility which probably occurred to Mr. Brassey and to others who have advocated this clause in the Treaty of Paris, that it appears at first sight we could. The only observation, therefore, which I have to make is this: that the impression Mr. Brassey desired to make, and very justly and very properly desired to make, that keeping up a very large force of unarmoured vessels of war was not required, owing to the effect of the Treaty of Paris, seems to me to stand on one leg.

Sir Spencer Robinson.

[1] It has been overcome by the organisation of the Royal Naval Reserve.

Sir Frederick Nicolson.

Sir FREDERICK NICOLSON, Bart., C.B., Vice-Admiral: Would you just allow me to say one word upon the point of what has been termed here the Treaty of Paris? I think that it is an erroneous expression to begin with; it never was a Treaty, it was only a declaration. There is one important point connected with it which we must not lose sight of, that the great maritime nation of the United States never agreed to it at all; they made counter proposals which were not accepted, and, therefore, so far as their trade is concerned, and I think that is perhaps the most important point to be remembered, they are not, and probably never will be, as matters stand at present, parties to that declaration. I call it a declaration because it is really only that and not a Treaty.

Admiral WILLIAM HOUSTON STEWART, C.B.: There is a very important point on which Captain Hall is able to speak with reference to the observations that fell from Mr. Reed as to the arming of the 'Inconstant.'

Commander Hall, R.N.

Captain HALL, R.N.: Some important remarks have been made upon the question of the armament of our unarmoured ships, and as I have given a good deal of attention to that subject, more especially to the armament of the 'Inconstant,' in which ship I once served, I should like to make a few remarks on the subject. Mr. Brassey, if I understood him rightly, advocated the arming of our merchant ships. Mr. Reed, on the other hand, was opposed to that, on the ground that it is necessary in unarmoured vessels to have heavy guns, and that merchant ships are not able to carry them. I venture, with all due deference to Mr. Reed, to think that it is not necessary in unarmoured ships to have heavy guns, a large number of what are called light shell-guns being in my opinion more efficient. I was always thankful I did not command the 'Inconstant,' for I confess I should not have known what to have done had I met with an ironclad. With such a powerful armament I should not have been justified in running away, and yet could not have engaged with any prospect of success, for every shrapnel shell or common shell striking the Inconstant' in any part, would have wrought fearful destruction, and striking at the water-line would in a few minutes have sunk her. Whereas the Palliser projectiles fired from the guns of the 'Inconstant,' would not in the same time do material injury to the ironclad. The 'Shah,' built since the 'Inconstant,' has been armed with a larger number of lighter guns, and if any gentleman will compare the broadside of the 'Shah' with that of the 'Inconstant,' he will find that in a given time the former ship can fire a greater number of common shell, carrying a much greater total quantity of powder, or a greater number of shrapnel shell containing a much larger number of balls, and he will I think be inclined to come to the opinion that the armament of the 'Shah' is more efficient when that ship encounters an unarmoured vessel than the armament of the 'Inconstant,' and that neither ship has much chance of success against an ironclad. If it be the fact that merchant steamers are unable to carry heavy guns, and I think they are unable, then those who advocate the arming of merchant steamers with guns must confine themselves to a limited number of light guns, as such vessels cannot carry more than a certain weight. Heavy guns necessitate a large amount

of machinery to work them, and it seems to me as a general rule, that guns worked by machinery should only be put on board ship in small numbers when they are behind armour. When they are not protected by armour one common or shrapnel shell may disable the gun. On the other hand the same weight of armament, but made up of a larger number of lighter guns, would, it seems to me, be much more efficient and less likely to be damaged, and in a given time would do more harm. I therefore venture to think that the assertion that a blight has fallen on the Admiralty with regard to their mode of arming our unarmoured vessels is not correct.

Mr. Reed: Allow me to say just one word of explanation. I should hardly like to be misapprehended, and Captain Hall has misunderstood what I said about the merchant vessels, at any rate. What I said was simply that you could not put heavy guns into merchant vessels, and that the only unarmoured vessels—that is to say, that could carry heavy guns—would be the naval vessels. I am quite aware of the view that he states, but I think I may draw from his speech this inference:—The 'Shah,' which he has compared with the 'Inconstant,' is now appointed, or is to be appointed, as we are informed in Parliament, to the South Coast of America. There the 'Shah' will encounter a number of little trivial ironclads, as regards both guns, thickness of armour, speed, and every other quality; and I have listened with pain to the argument from naval officers, that they would rather go and command the 'Shah,' in which they must of necessity run away from such vessels, than the 'Inconstant,' in which they could sink them. Sir E. J. Reed.

The President: I should be very sorry to interrupt any one who wishes to speak on this subject, because my only desire is to promote the objects of the meeting, and to get on with our business; but I cannot express the thanks which I think the whole of the meeting will accord to Mr. Brassey for his paper, without, in the first place, expressing my sense, in which I know many of you will join me, of the patriotic and able manner in which he devotes himself to these subjects. I think he is entitled to very great credit; and, therefore, it will really be to me a matter of the greatest regret if I find myself, on any important issue, to any extent differing in opinion from Mr. Brassey. But I must say that I should be sorry if the influence which a paper from Mr. Brassey would inevitably have in all quarters conversant with the matter was to be exerted in the direction of any serious discouragement of building unarmoured ships for the service of the British Navy. My own belief—and I am happy to find it confirmed by some of the ablest authorities who have spoken to-day—is that it is most desirable that the naval power of England should be supported by a great force of unarmoured ships; and I must say, with great submission to those who have expressed a different opinion, that I adhere to the opinion which I ventured to throw out in my address at the opening of the present session, and which I am happy to find confirmed by Mr. Reed, that, in my judgment, it is desirable that these unarmoured ships should be heavily armed. But I am in great hopes, if there is any difference of opinion between Mr. Brassey and myself with Lord Hampton.

regard to unarmoured ships, it is not of any serious extent; because I find Mr. Brassey saying that he 'should consider it unwise on the part of the Admiralty to build a greater number of vessels of this class than are absolutely necessary in order to meet the demands of the Foreign Office for protection to British interests abroad.' Why, gentlemen, there Mr. Brassey raises the whole question. We do not any of us want to build unnecessary unarmoured ships. Then Mr. Brassey again, in a subsequent passage in his address, says, 'These considèrations point to a policy of maintaining the smallest possible unarmoured Navy, consistently with its efficiency for the police of the seas.' There again you raise the whole question. We do not want useless vessels, but we do want to maintain the police of the seas; we do want to protect the commerce of England. That raises the serious question, whether or not, in the event of war with a maritime power, the protection of our commerce would not imperatively require a sufficient force of unarmoured vessels; and I hope that I may trace in these expressions of Mr. Brassey that it really is difficult to find a point, if there be one, where he and I would diverge, because I do not contend for any unnecessary amount of unarmoured vessels, but I do contend for such an amount of unarmoured vessels as may fully and fairly attain those great public objects which Mr. Brassey himself acknowledges to be necessary. There is one other point on which I cannot help, after these discussions, saying one word, which was referred to by Sir Frederick Grey, and that was Mr. Brassey's first point, that there must be a limit to expenditure. That is perfectly true; and, therefore, while I admit most broadly that it is for a great maritime Power like England to set the example of grand experiments in every direction which can extend or increase our naval power, at the same time—and I hope none of my friends here will take exception to what I say—I do want to see that great expenditure of England not thrown away in useless experiments, but devoted to the building of ships. I want to see ships, and not monsters built. I hope I shall not give offence to any one who hears these expressions, but I must say that my desire is to see ships built; and there is a phrase which has lately obtained on these subjects, which is a new one in nautical matters, which fully describes the character of vessels that I think we all should wish to see. We used to hear of good sailing ships, and good ships of various kinds, but there is a new phrase grown up of 'sea-keepers;' and I do hope that the Admiralty will consider the necessity of maintaining a class of vessels of such a strength that they shall be sea-keepers, and able to keep the seas; because when we look at that vessel which will be discussed presently, with every wish to pay full respect to whatever merits it may have, and when I see such vessels as the 'Devastation' and this vessel are costing huge sums of money, I cannot help feeling that those sums of money might be devoted to objects which would better insure our naval power, namely, the building of sea-keeping ships. My own belief is this, that you may build sea-keeping ships which, while they may be enabled to do good service on the ocean, will be equally available when brought home to our coasts to protect those coasts, and thus answer both purposes. I could not refrain

from throwing out these observations, but my wish is to see unarmoured vessels to a sufficient extent, and that the vessels on which we are spending huge sums of public money should be vessels available for the defence of England in all places and under all circumstances.

Mr. THOMAS BRASSEY, M.P.: My Lord, with your permission I will say two or three words in reply to what has been said. I am very much obliged to Lord Hampton for the interpretation which he was pleased to put upon my paper. He has rightly appreciated the policy which I ventured to recommend in the paper which I have read. I do not at all desire that our unarmoured fleet should be inadequate to the requirements of the country; but I do say this, that, in looking to the future, and making a provision for our future requirements, we should devote our main resources to vessels of whatever type is recommended to us by the naval men for fighting purposes, rather than to vessels the use and value of which is limited to the protection of our commerce. There must be present to the minds of everybody who considers these subjects, whether in or out of Parliament, the conviction that every vessel that you build in anticipation of a future want, immediately imposes on the naval estimates a very considerable burden for the repairs which are necessary to keep that ship in order. All admit that it is a regrettable feature in our naval expenditure that so large a proportion of the money so liberally and cheerfully voted by Parliament is applied, not to the creation of additional naval strength, but to the maintenance and to the repair of the ships which already exist. I say, therefore, that I would limit the number of unarmoured ships to the immediate requirements of the service, and so reduce the serious charge for repairs which the construction of those vessels involves. With regard to the training of our seamen, a consideration which Sir Frederick Grey put before us, and the value of which I am sure we must all appreciate, I venture to throw out this suggestion with great deference. I wish very much that we could go back, for mere training purposes, to vessels which should be purely sailing ships. I do not mean to suggest for one moment that there should be many such vessels in the Navy, but when I look to the valuable use to which brigs have been applied during the past winter in training the ordinary seamen of the Navy, who would otherwise have been spending their time on board the 'Duke of Wellington,' and other stationary vessels, I am perfectly convinced that we should carry that plan a little further, and that it would be an exceedingly valuable addition to our vessels for training purposes, if one or two sailing tenders were attached to each of the largest receiving ships in our home ports. I believe by that means you would keep your young sailors and young officers much more at sea than at present, and at a much less cost than is now incurred. Then with reference to our position at the outbreak of a war. Sir Frederick Grey has very properly put before us the necessity of giving adequate protection to our commerce in such an emergency. For that purpose I venture to say that we may look, not without some confidence, to the resources afforded by our merchant service. It may be that the greater number of our merchant steamers are not available, but I should be very much disappointed, if upon investigation,

The Compiler.

it was found that none were available. Anyhow we know this, that the subsidies to ocean mail services have been advocated, and granted freely and liberally by Germany, by France, and by the United States, especially the two former Powers, because it was thought by the Governments of those countries that if the time came, or the emergency arose, they would then be able to call upon those vessels to render valuable supplementary services for war. Surely if we give our large subsidies to the great ocean companies, without seeing that the vessels so subsidised by our Government are at least as fit for war as the vessels subsidised by other Powers, we shall have failed to make use of a valuable source of strength. My honourable friend, of course, spoke a word of affection for his own child, the 'Inconstant,' and I have to say to him that I would not pretend to enter into controversy with a man of his eminence as a naval architect upon such a subject, in reliance upon my own unaided judgment; but when I look to the last Report of the Committee of Naval Designs, and to the evidence tendered to that Committee by Captain Waddilove, I am justified, if I may follow the captain of the 'Inconstant' upon such a subject, in describing the results attained in the 'Inconstant' as only in a qualified sense successful. The coal-carrying capacity was pointed to by Captain Waddilove as unsatisfactory, and why? Because the 'Inconstant' at full speed could only steam two and a quarter days. If the 'Inconstant' is to be regarded as an ocean steamer for the protection of our commerce on the wide seas, I say that her coal-carrying capacity is not satisfactory. There is another objection which may be urged against a repetition of the 'Inconstant.' She is a very costly ship for the purpose for which she was designed. Bearing in mind, as we must, that after all our naval expenditure is not an unlimited quantity, we are brought to this issue, Are we to prefer one 'Inconstant' or two 'Volages,' or three vessels of an even more moderate size? You have to choose between the three alternatives. I do not recommend, I never have argued in favour of, a smaller vessel than the 'Inconstant,' because I wish to spend less on the Navy, but because I feel it important that you should have as numerous a fleet as you possibly can, provided it be composed of efficient vessels for our protection. Certain it is that, unless Parliament is prepared to add very largely indeed to the Naval Estimates of recent years, you are not justified in building unarmoured vessels of the 'Inconstant' type. If you do so, you produce a fleet not numerous enough to defend your commerce. The value of numbers, I think, has been greatly commended to us by the paper of Mr. Barnaby, for he has shown how much you may add to the strength of vessels like the 'Inflexible,' by surrounding them with groups of tenders to protect them against the attack of the torpedo That, again, I take to be a very strong argument in favour of building unarmoured vessels of as moderate a tonnage as is consistent with the purpose for which they are intended. I will not trespass further on the time of the meeting, except to say with reference to the controversy about guns, that in this, as in a great many other problems, a compromise is not an unwise solution of the difficulty. Why should not we have mixed armaments? French officers of very great experience have strongly advocated mixed armaments.

CHAPTER V.—(*Continued*).

UNARMOURED SHIPS.

SECTION III.

Armaments.

IN the *Times* of January 3, 1876, it is remarked by the able correspondent of that journal at Portsmouth, that our armour-plated fleet is armed with the most powerful and unerring guns in existence, but, when we examine the armaments of our unarmoured frigates, corvettes, and sloops, we find that there is not only no improvement being made, but that a rapid, persistent, and marked depreciation is apparent. These views are supported by an analysis of the armament of some of the most important of our unarmoured vessels. Comparing the 'Inconstant,' displacement 5,782 tons, with the 'Raleigh,' displacement 4,765 tons, the armament of the former consists of six 6½-ton guns on the upper deck, and ten 12-ton guns on the main deck, while the armament of the 'Raleigh' consists of two 12-ton guns and four 64-pounders on the upper deck, and fourteen 4½-ton guns and two 64-pounders on the main deck. The 'Shah,' with the same displacement as the 'Inconstant,' carries two 12-ton guns, sixteen 6½-ton guns, and eight 64-pounders. The 'Volage' and 'Active,' though originally armed with two 6½-ton guns, are now limited to the 64-pounder. The 'Boadicea' and 'Bacchante' carry each fourteen 4½-ton guns and two 64-pounders The corvettes of the 'Danae' class were formerly armed with two 6½-ton guns and four 64-pounders, and now carry twelve 64-pounders only. Similar changes have been adopted throughout the Navy for the sloops and the larger classes of composite gunboats.

Times Portsmouth Correspondent. January 3, 1876.

'Inconstant' and 'Raleigh.'

'Shah.'

'Volage' and 'Active.'

'Boadicea' and 'Bacchante.'

'Danae.'

The policy of the Admiralty in introducing these changes has been challenged on more than one occasion by powerful critics. The following letter was addressed by Sir Edward Reed to the *Times*, on September 30, 1874:—

Letter of Sir E. Reed, M.P., September 30, 1874.

'The repeated articles of your Portsmouth correspondent upon the "Raleigh" have invited public attention, with the ability and

accuracy which that gentleman's communications usually exhibit, to a subject of the most serious importance to our Navy, and, therefore, to the country. I refer to the substitution in our unarmoured frigates of what he, without exaggeration or unfairness, calls "a box of weak shell-guns," for the powerful armaments given to the earlier frigates of the class.

'It appears to me scarcely possible to exaggerate the evils into which the gunnery advisers of the Admiralty have led the late and, so far as I know, the present Admiralty in this respect; and I view with dismay the course which has been taken during the last year or two, under naval influence, by our Boards of Admiralty. For the displacement of powerful guns by weak ones has not been made in the frigate class only, but throughout the unarmoured fleet, and a perfect blight has fallen upon frigate, corvette, and sloop alike. The questions at issue may readily be made intelligible to all. Having to build very fast unarmoured ships, the first question was, shall we arm them with a few guns of great power and range, or with numerous guns with light penetrative power? The answer of a certain class of naval officers was that these ships are unfit to engage armoured ships, and should be treated as having to engage unarmoured ships like themselves, and for this purpose it is better to have numerous light shell-guns, which although weak in penetration, are sufficiently penetrating for the purpose, and have in the aggregate great explosive power. Our answer was that unarmoured ships are, at the best, but little fitted for withstanding any form of modern ordnance, and that these fast unarmoured ships were to serve other purposes than fighting pitched battles; that for all purposes of fighting with any class of ships, a concentrated battery of powerful guns would be at least equal to the outspread battery of lighter guns; and last, and most important of all, that a ship without armour, but with guns of great power, might on an emergency contend with those earlier armourclads, which could not resist her fire, especially where the non-armoured ships had greater advantages in point of speed.

'And now what is the result? The "Inconstant" and the "Raleigh" are finished ships, the former embodying the views of Sir Spencer and myself, and the latter the views of certain gunnery naval officers. A war breaks out, and every ironclad of every navy in the world, no matter how puny the navy or the ships be, may dare Her Britannic Majesty's large and modern steam frigate "Raleigh" to approach under any circumstances, in spite of all her size and all her speed. Or if the "Raleigh" dare approach at all, with

timidity and extreme caution, her boldness is due solely to the fact that we rescued the bow from the evil which befell the broadside, and succeeded in getting two powerful guns placed there. On the other hand, the "Inconstant," with her powerful broadsides of heavy guns, can destroy at least two-thirds of the ironclads of the world, and has scarcely more need to retreat from them than they have to avoid her, while in the heat of an action, or by night, or under other favourable circumstances, she might, with her tremendous speed and gun-power, sweep down upon them with terrible and glorious effect.

'The fact is, Sir, there has been, there is, and there will remain a very strong necessity for the resolute application of sound common sense to these naval questions, and to none more than to this one. There are arguments, undoubtedly, by which it can be shown that a light distributed armament is superior to a heavy concentrated one for these unarmoured ships. But there are other arguments, which show conclusively that there are diversified conditions of great probability, in which the presence of the light distributed armament, and the absence of the heavy concentrated one of armour-piercing guns, would involve our ships either in defeat, or in the worse disgrace of a retreat from foes of far inferior size, and it is earnestly to be hoped that the Government will prove themselves capable of taking a broad common-sense British view of the subject, rather than the narrow, niggling, Frenchified view, which has given our neighbours a more perfect, theoretical, and symmetrical fleet than ours, but one to which we look in vain for such embodiments of power as are exhibited in the "Hercules," "Sultan," "Devastation," and "Fury," or such combinations of power and fleetness as the "Inconstant" presents, and as I once fondly hoped her successors would be allowed to present likewise. It must be stated that the present Government have not yet dealt as we could hope with this subject, and the sooner they set about it, and insist on employing guns of greater penetrating power, wherever possible, in the fleet, the better for themselves and the country.

'Before concluding this letter I will advert to one other question referred to by your correspondent, for it exhibits the degree of folly which we have still to guard against in our navy. It is well known now that, in order to give war ships very steady gun-platforms, it is absolutely necessary to give them small initial stability, and the inevitable consequence is that they yield easily to the pressure of their canvas through moderate angles of inclination. It would be quite easy to make them stiffer under canvas, but the necessary consequence would be diminished steadiness of gun-platform. Now in

unarmoured ships, which are without side defence, it is obviously most desirable to make the fire of their guns astern as deadly as possible, and the 'Inconstant" is a striking example of the perfection which may be attained, as regards steadiness of gun-platform, when initial stiffness under sail is sacrificed. The "Raleigh" is, I am informed, an equally successful ship in this respect, but instead of appreciation of this primary and invaluable quality of steadiness of gun-platform, what do we hear? "That she exhibits a crankness under sail that must materially detract from the power of her guns." It is perfectly obvious that such an objection can only arise out of the assumption that modern ships, with supreme steaming powers like the "Raleigh," are to fight their actions, not under steam, but under sail. Can the force of unintelligent complaint and criticism, or rather cavil, go further? No doubt steam machinery is liable to derangement in war, and the necessity for resorting to canvas in battle may arise; but this is a contingency so entirely secondary, and inferior to the fighting power under steam, that he would be wrong-headed and perverse indeed who sacrificed the latter to it.'

Sir Spencer Robinson.

Sir Spencer Robinson is another high authority in support of the same view. Referring to the 'Inconstant,' he said she was supplied with armour-piercing guns; her speed enabling her to close with anything she wished to destroy; her speed and armament combined enabling her to harass and keep at a distance the superior force even of an ironclad, without any serious risk to herself.

'Seaman Gunner.'

Sir E. Reed's letter attracted great attention at the time, and led to an animated correspondence between himself and a writer, who, under the anonymous signature of 'Seaman Gunner,' defended the policy which the Admiralty had adopted in the armament of our unarmoured ships. 'Seaman Gunner' assumed that such vessels as the 'Inconstant' would avoid engaging armourclad ships. Hence he argued that the armament of such ships as the 'Inconstant' or the 'Raleigh' should be of a nature best calculated to produce a destructive effect upon unarmoured vessels. For this purpose many light guns were preferable to a smaller number of armour-piercing guns, rapidity of fire, combined with accurate firing and large shell-power, being points of paramount importance.

The 'Raleigh' has 1,020 tons less displacement than the 'Inconstant,' and has a broadside of twelve guns, while the broadside of the 'Inconstant' consists of nine guns. Hence the rapidity of fire and chances of striking an enemy's ship will be considerably greater in the 'Raleigh,' while the total amount of bursting charges contained in one broadside of common shell from the 'Raleigh' is only 7 lbs. less than that of the 'Inconstant.'

Admiral Scott.

At the session of the Institute of Naval Architects in the following year, Admiral Scott, in commenting on the controversy which had been raised between Sir E. Reed and 'Seaman Gunner,' delivered a well-balanced judgment on the points in dispute. 'The question for our consideration is how much are we inclined to give up in order to have more powerful guns? That is the principal question. It is the question which has been debated in the papers, and no doubt you have seen the correspondence between "Seaman Gunner" and Mr. Reed. With respect to this correspondence, I may say that "Seaman Gunner" has gone on the assumption of the advantages being on the side of numerous light guns, as against fewer and more powerful guns. Our unarmoured vessels are few and far between at the present time, and if they can be chased off the seas by lightly armoured hostile cruisers, whether Chinamen or Brazilian—I only name these as an illustration, and not desiring to say a word against either of those nations—what protection will they be to our commerce? The "Raleigh" is mainly armed with light guns of very little power. Such guns will have no effect whatever against an ironclad; but a new "Raleigh" with the same tonnage could carry four 18-ton guns, and might in addition be perfectly well armed against the attacks of torpedo and other vessels. But, on the one hand—and that is a great difficulty in the way of constructors—they have to contend with those who go in entirely for a few very heavy guns, and on the other hand, to contend with those who go in for a large number of light guns only; I think both are mistaken. You really want light guns and also heavy guns; the large gun alone will not be able to maintain its fire against a number of well directed small guns discharged at it. In the contest, however, which has been carried on in the public papers as to heavy or light guns, it seems to me to have been entirely left out of consideration that the shell of the heavy gun is far stronger than the shell of the light gun. I think it is probable that, in striking at an acute angle, every one of the light shells would break up. I believe 1-inch thickness of side armour would break them up to a certainty; and I am not at all sure that on a light shell striking the side of an unarmoured vessel the same effect would not be produced. On the other hand a heavy shell will generally penetrate, and if it penetrates, will produce a far greater effect. There is another point, which is this, that the heavy gun has greater accuracy, a flatter trajectory, and more power, and therefore it is much better for the main armament. Another consideration with regard to having a number of light guns is that the smoke from one gun interferes with the pointing of the others. I think you would find that a great mistake had been committed were

one of our unarmoured vessels to meet (as it would be sure to do on the declaration of war) with small ironclads, and be obliged to retreat, for she could do nothing with small guns.'

M. Dislère.

M. Dislère agrees with 'Seaman Gunner,' Captain Hall, and others, who have been quoted, 'that cruising ships are not required to engage with ironclads in the line of battle.' Against the latter, moreover, the gun of 19 c/m., weighing eight tons, which is the heaviest gun he recommends for unarmoured vessels, would be just as ineffective as the 16 c/m. or 5-ton gun.

Admiral Waddilove.

In his evidence before the Commission on Designs in 1870, Admiral Waddilove, who was then in command of the 'Inconstant,' expressed an opinion that the armament of the 'Inconstant,' consisting of 9-inch 12-ton guns, was too heavy for the protection of commerce, while, on the other hand, the absence of armour-protection made it impossible to engage on equal terms with the least powerful type of armoured vessel.

Necessity for long-range guns.

In connection with the subject of armament the question of range is of very high importance. In the armament of unarmoured ships, which are to engage other unarmoured ships, it is not so much penetrative power as long range that is required. In commenting upon the great improvements introduced by Sir William Armstrong, Mr. King, of the United States Navy, remarks, 'There are situations in war where accurate shooting at long range is of the utmost value, and a high initial velocity given to a projectile means longer effective range and better shooting at all ranges. A 70-lb. shot from the new 6-inch rifle is estimated to penetrate eight inches of iron at a distance of a quarter of a mile, and the reported range is 2,713 yards, fixed with an elevation of three degrees, and 3,795 yards, fixed at an elevation of five degrees.' Admiral Randolph, in his lecture on 'End-on Fire,' confirms the opinion expressed by Mr. King. He considers that the long-range chase gun is absolutely necessary for the fast and light ships, which will keep the police of the seas. In his treatise on *Naval Gunnery*, Sir Howard Douglas said, that 'a ship having an armament which is deficient in point of range will have to endure the serious ordeal of much distant firing.' It appeared to him to be a great mistake to suppose that the propulsive power of steam and the effects anticipated from shell-guns would cause actions at sea to take place at close quarters only, and to be decided in a few minutes.

Mr. King, Chief Engineer, U.S.N.

Admiral Randolph.

Sir Howard Douglas.

General conclusion in favour of a mixed armament.

An impartial examination of the most competent authorities would seem to lead to the conclusion that for all ships of war, and especially for unarmoured vessels, a mixed armament of long range and armour-piercing ordnance, combined with lighter guns, is to be

desired. The cruiser should be so armed as to be able to engage successfully a ship of the same class, and in such an engagement rapidity of fire is of the greatest importance.

Admiral Scott, in his remarks on Mr. Barnaby's paper on the 'Best Types of Ships of War,' recommended that no ship should be armed exclusively with heavy ordnance. Without a proportion of light and quick-working guns she was liable to be destroyed by the attack of torpedo boats. He proceeded to illustrate his views in detail by suggesting an improved armament for the 'Raleigh.' 'That ship,' he said, 'could have mounted, in addition to six 18-ton guns, four powerful 64-pounder breech-loading guns, firing large charges of powder, with steel shell, which would pierce ordinary armour, and also with the destructive double shell. In addition to these guns she could have mounted four breach-loading anti-torpedo 20-pounders, giving very great elevation and depression, which would altogether make about 180 tons, instead of the 181 tons of her present guns. The supply of powder and projectiles would weigh about 218 tons, giving a total of 398 tons, so that the 'Raleigh' could have been locally strengthened, and been then given a most powerful armament, well adapted for all the purposes of warfare without any increase of weight. A war vessel should be prepared to fight an enemy ahead or to fight an enemy astern; in fact, the man-of-war should be prepared at any and at all points; and she should be so armed as in any position to be able to bring the greater number of her guns to bear in every direction.' Admiral Scott.

Captain Noel, in his prize essay, says:—'The armament of our ocean cruisers must necessarily be lighter than that of our ironclads, but the battery of the larger ones should consist of much the same guns as those of the "Shah," except that a frigate of her size, with greater beam, must carry 6½-ton 7-inch guns, instead of 4½-ton shell-guns on her main deck. The armament of the "Amethyst" is formidable, but a vessel of her displacement should carry twenty 64-pounders instead of fourteen.' Captain Noel, R.N.

In the discussion on the *Naval Prize Essay of* 1878, at the United Service Institution, on June 21, 1878, Admiral Ryder said:—'Then as to the question whether many light or few heavy guns should form the armament, I think we ought to have both. It is absurd to give us only a few heavy guns, and no light guns. We shall often be attacked by small swift vessels. We want, in order to meet all comers, a few heavy guns and a great many light guns.' Replying to the question whether ships should be armed to fight only their own or other classes, he answered. 'I think primarily Admiral Ryder.

their own, but we should have at least one powerful gun on board each vessel to give little vessels a chance, when they are overtaken, as will often be now, because the small vessels have the inferiority in speed, except the new torpedo-vessels, and unless the small vessel, corvette, or gun-vessel, can get a big gun into play she will be run over or captured.'

Captain Fremantle.

The extreme uncertainty and inaccuracy of fire in a naval action, except at close quarters, makes it the more important that the armament of our ships should be numerically strong. In his prize essay Captain Fremantle is very decided on this point. 'The old adage,' he says, 'about "not putting all your eggs into one basket," applies equally to guns as to ships. As Nelson said, "In a naval action something must be left to chance, and those who fire the largest number of shots must have the greatest number of chances."'

Captain Noel.

Commander Noel, in his essay on *Great Britain's Maritime Power*, shows by an elaborate table that thirty 12-ton guns might in ten minutes fire fifty tons weight of shot, with a total energy of 696,600 foot-tons at 4,000 yards, twenty 18-ton guns in the same time throwing thirty tons weight of shot, with a total energy of 454,750 foot-tons, at the same distance. In the case of the 12-ton guns there are reasons for supposing that the data taken by Commander Noel from the prize firing of the 'Iron Duke' and 'Triumph' are unusually favourable, and there is certainly some virtue in having the larger gun where the disproportion of weight of shot and energy is not considerable. Further, we know from official data that the 12-ton gun will penetrate 11½ inches of unbacked iron armour at the muzzle, 9½ inches at 1,000 yards, and eight inches at 2,000 yards, while the 18-ton gun will penetrate 13 inches, 11·6 inches, and 10·5 inches respectively under similar conditions. It will be found, then, that at 4,000 yards, the distance taken by Commander Noel, the penetration of the 18-ton gun would be 8·7 inches against six inches for the 12-ton gun, and at that distance the actual penetration of armour-plating would stand, in round numbers, as 3·949,800 inches for the 18-ton gun, against 4·176,000 inches for the 12-ton gun, thus reducing the two guns to almost an equality.

In the discussion at the United Service Institution, on the *Naval Essays of* 1878, the recent engagements between the 'Shah,' the 'Amethyst,' and 'Huascar' was naturally a prominent topic. Captain Colomb said:—

Captain Colomb. 'Shah' and 'Huascar.'

'Now what happened on that occasion? The "Shah" and

"Amethyst" fought the "Huascar" at distances varying from 300 to 1,900 and 2,000 yards. The "Huascar" had two heavy guns, and the "Shah" had two heavy guns. The "Shah" had also sixteen heavy guns of a smaller calibre than either of the "Huascar's" large ones, or the "Shah's" large ones. They fought for 2½ hours. At the end of that time (comparing all the accounts that have come forward) I find that this is the measure of the damage done to the "Huascar." She was hulled by four 9-inch projectiles, and two 7-inch; she was struck in various places by eight others, of various calibres; four went through the funnel, therefore you could hardly say she was hulled in that case. This leaves you nine shots which struck her, and of course some of the 64-pounders, but they are not specified, and there are no means of ascertaining whether the abrasions of the iron were due to the broken pieces of shells, or to projectiles directly fired at the ship; but numbers of them were certainly ricochetted. She was, however, struck nine times, and practically she was not much hurt; she had one man killed and one wounded. What was the expenditure of ammunition? The "Shah" fired 241 shots, 32 9-inch and 149 7-inch shot and shell at the "Huascar." The "Amethyst" fired 190 shot at her. The Admiral expresses surprise and thankfulness that the "Shah" was not struck. The "Huascar" appears to have fired eight times at the "Shah." Considering that out of 421 projectiles only nine took effect on the "Huascar," I do not quite see that it was a matter of surprise that no shot out of eight struck the "Shah." It will be said, "You are throwing a reproach upon the gunnery of your own ships." No; I am quite satisfied the gunnery of our ships is the best gunnery in the world, and I have no doubt everything was done that was right in both those ships of ours on that occasion. The percentage of shot which took effect is nearly the percentage which I stated some years ago in this Institution would take effect. I said, "About two per cent. of your shot will strike your object in action," and there is the whole thing. But now the point is, what good were the "Shah's" two heavy guns to fight an armoured ship like the "Huascar"? And that goes to support what Captain Price, and what I am glad to find most people who have gone some distance into the figures with me, come to, that practically one or two guns are not much good in any case whatever, that the inaccuracy of fire is so large an element that it is not much use having so few guns, and that unless you can show a broadside of some six guns, you do not get much value. You cannot do much with it, your shot is thrown away.

'Reverting for a moment to the question of the few heavy or the

many light guns, and going to that further question, should a ship be armed to fight one of her class, or to fight every other ship,—if we imagine the "Shah," armed with two or three heavy guns, meeting another "Shah" of her size, with three or four times as many light guns, we should feel that the "Shah" was not properly armed, because the very first action between those two ships would utterly defeat, destroy, and demoralise the "Shah" with the few heavy guns, while the "Shah" with the many light guns would have become triumphant. It would have been no disgrace to a ship to have been beaten off by a ship that she was not intended to fight, but it would be a lasting and burning disgrace, and destructive to our prestige, as it was in the American war, if she were beaten by another ship of her class. The people of this country would not go into the details of the nature of the guns; they would find the ship was of a certain size, and of such and such a class, and if she was beaten, there would be the same outcry that there was in the American war.'

Broad Arrow, July 13, 1878. The advantages of a mixed armament were strongly urged in the *Broad Arrow* of July 13, 1878:—'For first-class fighting ships there has of late years been a growing tendency to reduce the number and increase the power of the guns carried. In 1858 the first-class fighting ship mounted 131 guns, ranging from 68-pounders to 32-pounders. In 1862, twenty guns, each of 6½ tons in weight, was the most powerful armament carried. In 1872, eight guns, each of 18 tons in weight, were carried by ships then being put into commission for the first time. After that four 25-ton guns, next two of 35 tons, and then four of 80 tons, were successively the armaments of first-class fighting ships, the last-named being the offensive weapons of the "Inflexible." There is nothing to prevent the size of the gun from still increasing, for it would be an easy matter to provide a floating fighting platform for guns of even 200 tons in weight. But *cui bono*? If a ram or torpedo will sink a ship with one, or at the most two, blows, why go to the expense and trouble of constructing enormous guns, which cannot be so accurately depended upon to do the same thing? Besides, the great majority of European war ships can be readily penetrated by 18 and even 12½-ton guns, while even a 68-pounder, judiciously employed, could put unarmoured vessels like the "Shah" and "Inconstant" *hors de combat*. Hence it will be seen that there is a necessity for carrying guns of small as well as of large calibre and weight. There is, however, another way of looking at the matter. With four guns on a broadside, there is four times the chance of striking an enemy as with only one gun;

and, if each of these four guns can send a projectile through the vital part of the enemy's side, there is obviously less than no use at all in employing an individual large gun.'

Conclusion in favour of a mixed armament.

The above citations from writers, who have considered the question of armament from various points of view, and with different measures of responsibility, some being engaged directly in the service of the Admiralty, others occupying the position of outside critics, others holding responsible positions in connection with foreign navies, all tend, as it has already been said, to establish the conclusion that every unarmoured ship, which is capable of carrying a heavy long-range armour-piercing gun, should be armed with a due proportion of weapons, which will enable them to engage an armoured vessel with some prospect of inflicting damage upon the most powerful antagonist. All unarmoured vessels should have a certain proportion of armour-piercing guns. On the other hand, rapidity of fire is an advantage under many contingencies in an engagement between armoured ships, and it becomes an object of vital importance in an engagement at close quarters between unarmoured vessels.

Armaments should be improved by introducing the new guns of Sir William Armstrong.

It is obvious that the armament of the smaller classes of unarmoured ships might be rendered much more powerful, without any increase in the weights to be carried, by making use of the recent important discoveries and improvements in the science of gunnery. Sir William Armstrong's 6-inch breech-loader has 50 per cent. armour-piercing power more than the Fraser 7-inch muzzle-loader, the latter being more than 50 per cent. heavier. Sir William Armstrong's gun, though weighing only four tons, is capable of piercing eleven inches of armour. 'It appears to us,' says the *Engineer*, in a recent article on the 'Duilio' explosion, 'as if recent events had combined rather to give a check to the manufacture of very heavy guns. The introduction and development of large charges of slow-burning powder has tended to encourage increase in length rather than in calibre and absolute weight, so that long guns of comparatively small calibre have obtained results out of proportion to their weight. With the introduction of breech-loaders this is likely to increase, and, what is of special importance with a view to extending the practical range of effective artillery fire, accuracy improves also. At Shoeburyness, not long ago, the new 8-inch breech-loading Elswick gun, fired at 5°, obtained the remarkable results of a range of over 4,500 yards, with an error in range of about ten yards, and deflection of about four feet. At 12°, a range of nearly 7,700 yards was obtained, with errors of about double the magnitude of those at the shorter range.

Armaments, 'Vandalia' and 'Garnet,' new and old guns.

In order to show how materially the power of naval guns has been increased by the recent improvements, we may refer to the report of Mr. King, the Chief Engineer of the United States Navy, giving the comparative power of our 'Opal' class armed with the new type of guns, and the 'Vandalia' type of the United States Navy, armed with the smooth-bore guns still in use in the United States Navy.

The following table is taken from Mr. King:—

	'Vandalia'	'Garnet'
Displacement . .	2,080 tons	2,162 tons
Length . . .	216 feet	220 feet
Breadth . . .	39 feet	40 feet
Mean draught of water .	$17\frac{1}{3}$ feet	$16\frac{1}{4}$ feet
Speed, maximum . .	12 knots.	12 knots.

VANDALIA.

Batteries of Smooth-bore Guns.

One 11-inch smooth-bore	
Six 9-inch smooth-bore	
One 5·3-inch rifle 'Parrot'	
Weight[1] of guns	34 tons
Tons displacement to ton of battery .	61
Weight of broadside projectiles . .	414 lbs.
Range of 11-inch at 3° . . .	1,270 yards
" " at 5° . . .	1,811 yards
Initial velocity	1,038 feet
Range of 9-inch at 3°	1,302 yards
" " at 5°	1,864 yards
Initial velocity	1,050 yards

GARNET.

Batteries. New Rifled Guns.

Ten 6-inch rifles, new pattern . . .	38·5 tons
Two smaller rifles	3·5 tons
Weight of guns	42 tons
" 6-inch projectile . . .	70 lbs.
Tons displacement to ton of battery .	44·4
Weight of broadside projectiles . .	420 lbs.
Range of 6-inch at 3°	2,713 yards
" " at 5°	3,795 yards
Initial velocity	2,000 feet

Advantages of a light armament.

The aggressive force of the battery of a ship of war was formerly estimated by the weight of metal discharged on the broadside, but of what avail would be any weight so discharged, if the enemy possessed

[1] This weight is that of the guns only. The aggregate weight of the battery, including carriages, carried on the decks of a ship must be limited, and should be in proportion to tonnage-displacement.

superior speed and guns having much longer range and greater penetrating power of projectiles? Here are two vessels nearly equal in speed, displacement, and weight of broadside projectile. The one 'Vandalia,' is armed with seven cast-iron smooth-bore guns, having ranges at 5° respectively of 1,811 and 1,864 yards, and velocity of projectiles of 1,050 and 1,038; while the smaller 'Garnet' carries twelve rifles, ten of which have the range at 5° of 3,795 yards, and velocity of projectiles of 2,000 feet, or an average range of 1,692 yards greater than those of the 'Vandalia,' or more than double, and an initial velocity of projectiles of 2,000 feet per second, against 1,038 feet. In addition to which two other advantages are possessed by the 'Garnet,' one being lighter guns to handle, consequently more rapid fire, and the other, the system of mounting two of the guns forward and two aft, to fire on the line with the keel or on the broadside as desired.

Considerable changes are being made in the armament of the United States Navy; the breech-loading rifled guns, converted on the Palliser system, are being substituted for the cast-iron smooth-bores.

Coefficient of weight of armament. In the British service, in the distribution of the weight forming the load displacement, a much larger proportion is assigned to the guns than in the French ships. The coefficient of the weight of the guns is 40/1,000 for the 'Infernet' class, 50/1,000 for the 'Duquesne,' and 82/1,000 for the 'Shah.' The loss of the French ships in battery strength is said by Lieutenant Very, U.S., to be remedied in a manner by superior velocity of projectiles, and rapidity of fire, which is made possible by centre pivoting and breech-loading. **Methods of mounting.** In the methods of mounting their guns, by means of half turrets and centre pivots, Lieutenant Very considers that the French system presents advantages over the long pivot circles permitted in other navies, which in the smaller classes tend to list the ship.

CHAPTER V.—(*Continued*).

UNARMOURED SHIPS.

SECTION IV.

Speed and Coal Endurance.

In France for some years it has been recommended by numerous writers on naval questions, that in future naval wars the attempt to fight pitched battles on the ocean should be abandoned. They have urged that it should be the aim of their shipbuilding policy to provide for the defence of their coasts, and to attack the enemy in his commerce. We do not recognise any disposition on the part of the responsible authorities of the French Navy to abandon the construction of ships for the line of battle, in deference to the views of theoretical writers. But while they have carried forward the construction of armoured ships with increased energy, they have been rapidly creating fleets of unarmoured vessels, more lightly rigged and armed than ours, less efficient cruisers, far less able to fight a naval duel, but yet surpassing us in speed. While in France the resources of the Naval Administration are still being devoted mainly to battle ships, in Russia the destruction of commerce rather than the nobler aim of winning victories in pitched battles, has been the primary aim of recent naval policy. With this view cruisers, protected and unprotected, with considerable speed and coal-endurance, have been rapidly multiplied. As in the case of the Popoffkas and the belted cruisers, so in her wooden cruisers Russia has followed an architectural line of notable independence, not always leading to success, building so-called 'clippers' of a type differing considerably from any found in other European navies. The idea apparently was to provide rapid ships with a few long-range guns, able to make protracted voyages, and prey on an enemy's commerce. This idea has been well followed up of late, by purchasing from native companies, and from owners and builders in the United States and Germany, fast merchant steamers of great coal-carrying capacity, and by building in the Government dockyard cruisers of the 'Rasboynik' class, having an average speed of thirteen to fourteen knots.

Russia: Unarmoured shipping.

We have therefore to consider what shall be our own policy in this matter. It is to no purpose that we are able to fight, if we are

too slow to catch an enemy, and when we see that other Powers have at their disposal a numerous fleet of unarmoured ships, which by their speed can elude the grasp of our own more powerful but less agile vessels, it becomes imperatively necessary to build for the navy some ships of the class lately designed by the Council of Construction, three of which have been ordered by the present Board. But the deficiency in our force of swift ships is such that it has become a grave question whether to organise a reserve of cruisers in the mercantile marine, or to build for the navy a number of ships which are indeed essential for the protection of commerce, in the absence of other means, but which will have little to recommend them but their speed. To build such ships in numbers is to deduct seriously from the inadequate sum at our disposal for the construction of fighting ships. It is from this point of view that the plan of mercantile auxiliaries commends itself as an inexpensive and fairly satisfactory resource.

It seems almost superfluous to observe that it is not intended in the present paper to cast any reflection on the Construction Department. Foreign critics are loud in their commendation of the skill and variety of resource which have been displayed in the armoured construction of the British Navy. If we ask Mr. Barnaby to build for us a swift ship, he can build one; if we want economy in power, and the correlative quality of large coal-endurance, he can give it; but what Mr. Barnaby cannot do is to combine great sail-carrying and gun-carrying power with equal speed in a vessel of the same displacement with one in which the spars and the armament have been sacrificed to a quality more essential than either for privateering, namely, speed under steam.

Before entering on any detailed observations it may be convenient to give a short tabular statement of the unarmoured cruising ships in the principal fleets of the world:—

Unarmoured Ships. (Cruisers of the new types.)

Countries	Group I.	Group II.	Group III.	Total	Other Cruisers perhaps still efficient	Group IV. the newer Gun-vessels
France	3	22	21	46	6	3
Germany	2	15	0	17	0	2
Italy	1	2	3	6	0	2
Austria	2	4	3	9	0	2
Russia	7[1]	2	7	16	0	0
United States	(?) 1	(?) 2	(?) 1	4	(?)	(?) 0
Total Foreign	16	47	35	98	—	9
England	11	30	24	65	—	11

[1] Purchased cruisers are included in the figures for Russia.

Dividing the unarmoured cruisers according to their speed, we have:—

	18 knots	16 knots	15 knots	14 knots	13 knots
England	2	2	4	3	20
France	—	3	—	22	—
Germany	—	2	6	1	—

Of cruisers capable of steaming fourteen knots, England has eleven, and France twenty-five.

Speed depends on model.

For the protection of the great trade routes we require ships at least equal in speed and endurance to those of any possible enemy. The speed of ships depends not only upon powerful machinery, but on the model of the hull, and all experience tends to show that any given speed will be obtained with a smaller effort in ships with fine lines than in ships with full lines.

Illustrations from *Ironclad Ships*, by Sir E. J. Reed.

Additional length in the bow will give an increase of speed, with the same engine-power. Of this, many examples may be quoted from the older steamships in the navy. The following cases are taken from Sir E. Reed's work on ironclad ships:—

'The speed of the "Agamemnon," designed in 1849, and of the "St. Jean d'Acre,' designed in 1850, but little exceeded eleven knots. The "Hero," built in 1854, had a bow lengthened five feet from the "Agamemnon's," and went nearly eleven and a half knots. In 1856 followed the "Renown," lengthened ten feet amidships from the "Hero," which went over eleven and three-quarter knots. Meanwhile, in 1854, the three-decker "Victoria" was designed, and attained a speed of twelve and a quarter knots at load-draught. She was followed by the "Howe," made fifteen feet longer at the bow, the latter ship attaining, when flying quite light, without masts, armament, or stores, a speed of thirteen and a half knots. This speed, however, undoubtedly much exceeded the speed which would have been secured with the ship rigged and loaded for sea.'

Comparison of 'Duilio' and 'Inflexible.'

The advantages of fine lines as an element of speed have been recently illustrated in the case of armoured vessels of the largest tonnage. The 'Duilio' steams one knot faster than the 'Inflexible.' The 'Inflexible' is 320 feet long, 75 feet wide, and 24 feet mean draught of water. The 'Duilio' is 340 feet long, 65 feet wide, and 28 feet mean draught. The Italian ship has 20 feet more length and 10 feet less beam than the 'Inflexible.' The dimensions are more favourable for speed, and afford more space for machinery. On the other hand, the initial stability, by the reduction of beam, is lessened in a serious degree. Sir E. Reed has predicted that, if the

armour were pierced, the 'Duilio' must capsize. It is necessary to observe that these results may be modified by later trials.

Report on Maritime Section, Paris Exhibition, 1877.

The last report of the Secretary of the United States Navy contains an elaborate memorandum on the English and French unarmoured cruisers by Lieutenant Very, an officer who was officially appointed to report on the maritime section of the International Exhibition at Paris of 1877. The comparison in the intermediate classes, which comprise the greatest number of ships, is unfavourable to England as regards the quality of speed. It should be explained, before entering into the details of Lieutenant Very's paper, that the English Admiralty did not exhibit at Paris, while the French administration was very fully represented. The comparison, therefore, was made under conditions scarcely calculated to secure full justice for our own constructors.

French constructors opposed to large tonnage for unarmoured cruisers.

In the construction of large unarmoured ships the French have followed us slowly and with reluctance. Amongst French constructors a general concurrence of opinion is found in favour of ships of more moderate dimensions. They think that the difficulty of the shipbuilding problem, and the merit of the solution, consist in the creation of types in which fighting power and speed are combined with the smallest dimensions. Entertaining these views, the French authorities postponed the commencement of large unarmoured ships until the year 1871, when designs were prepared by Mons. Lebelin de Dionne for the 'Duquesne,' of 5,400 tons. The 'Duquense' was shortly followed by the 'Tourville.'

The 'Inconstant' and 'Tourville.'

The 'Inconstant,' our largest unarmoured cruiser, has a considerable superiority over the French first-class cruiser 'Tourville' in armament, and with her high speed of sixteen and a half knots is equal to the French ship in steaming qualities. Both ships are alike deficient in coal-endurance. The coal-endurance of the 'Inconstant' at full speed is 1,500 knots, and 2,400 miles at ten knots. The principal statistics of the 'Inconstant' are: length 337 feet, beam 50 ft. 3½ in., displacement 5,328 tons, indicated horse-power 7,361. 'Tourville': length 327 feet, beam 50 feet, displacement 5,352 tons, indicated horse-power 7,340.

'Shah,' 'Raleigh,' 'Duquesne,' 'Tourville.'

Two other unarmoured cruisers of the same class, the 'Shah' and 'Raleigh,' have been built for our own service. Let us compare them with the two rival ships which have been completed for the French navy. The speeds of the 'Shah,' 'Raleigh,' 'Duquesne,' and 'Tourville' are given by Lieutenant Very at 16·93 knots for the two French ships, 16·49 for the 'Shah,' and 15·32 for the 'Raleigh.' The displacement of the 'Duquesne' and 'Tourville' is 5,340 tons, the length between perpendiculars 327 feet, the beam 50 feet, the

mean load-draught 22 ft. 7 in., and the horse-power 7,340. The displacement of the 'Shah' is 5,900 tons, the length 334·8 feet, the beam 52 feet, the mean load-draught 23 feet, and the horse-power 7,500. The displacement of the 'Raleigh' is 4,680 tons, the length 298 feet, the breadth 48 ft. 6 in., the mean load-draught 22 feet, and the horse-power 6,000.

Coal-endurance.

Let us pass from the comparison of speed to the scarcely less important subject of coal-endurance. The 'Inconstant' and 'Duquesne,' as we have seen, 'can traverse 2,400 miles at ten knots.' 'The coal endurance of the "Shah" is equal to four days at full speed, and nine with half-boiler power.' At twelve knots—probably a too favourable estimate for continuous steaming—the distance traversable is 2,600 miles.

'Shah.'

The importance of coal-endurance was strikingly illustrated when the 'Shah' was engaged in the pursuit of the 'Huascar.' The 'Shah' was under way for nine days only at the low speed of ten knots, and yet Admiral De Horsey reported, shortly before his encounter with the 'Huascar,' that 'the "Shah's" coal-supply getting short now began to be a serious consideration.' With empty bunkers the ship would undoubtedly have fallen an easy prey to the Peruvian ironclad ram. None of our first and second class cruisers, comprising the 'Inconstant,' 'Shah,' 'Raleigh' 'Boadicea,' 'Bacchante,' 'Euryalus,' 'Rover,' 'Active,' and 'Volage,' could steam at twelve knots to any stations on the further shores of the Atlantic, nor keep going at full speed for five days. The 'Iris' and 'Mercury' compare very favourably with the older ships in coal-endurance. They can steam 5,000 miles at twelve knots, or about the distance to Halifax and back. The 'Gem' class can steam for ten days at 10½ knots. The wooden sloops of the 'Blanche' class can steam eight days at the same speed.

Size not necessary to secure coal-endurance.

Immense size is not an absolutely necessary element of prolonged coal-endurance. The 'Infernet,' of 1,920 tons, can steam 4,900 miles, and the 'Sané,' of 1,910 tons, 5,300 miles, in each case at ten knots. In their earliest screw frigates and ships of the line, the French had the same power of coal-endurance as they now have in the cruisers of the intermediate classes. Sir Howard Douglas, in his essay on naval warfare with steam, gave the average number of days' steaming at full power as follows:—

Naval warfare with steam.

British ships of the		121 guns class		. . .	8 days
"	"	90 guns, of the	'Renown' class	.	6 "
"	"	51	" 'Impérieuse' class	.	8¾ "
"	"	32	" 'Diadem' class	.	6 "
French	"	90	" 'Napoléon' class	.	10 "

The 'Napoléon' at full speed steamed 12½ knots per hour.

The deficient coal-endurance of our vessels has been often deplored by naval writers. In his prize essay, Captain Colomb asserts that of all our thirty-eight sloops scattered over the world there is hardly one which could steam 1,500 miles against a trade wind or monsoon. The heavy rig of our large unarmoured ships involves a serious sacrifice in the essential feature of the coal-supply in order to gain less essential qualities as cruisers under canvas. Captain Colomb, in the same essay, says, 'Take the exceedingly persistent struggle to produce "cruisers" which shall be perfect sailing vessels as well as perfect steamers, but necessarily sacrificing coal stowage, steadiness of platform, offensive or defensive power. It is manifest that if the full rig of any ship be reduced to an insignificant auxiliary she may be made by so much the more powerful a fighting ship. Our enemies' "cruisers" will be forced to carry a sail-power which is not necessary to us. When we submit our fighting ships to the inconvenience of full rigs, are we not throwing away one of the advantages of our naval position?'

Unarmoured ships too heavily rigged.

The inferiority of our cruisers to ships of equal dimensions in the merchant service in coal-endurance is easily explained. In the mercantile marine we never find the large spread of canvas which has been given to the cruising ships of the Navy, and which implies a proportionate increase of beam. The merchant steamer is not encumbered with the heavy top weight of a powerful armament carried at a considerable height above water. It is by increasing the length in proportion to the beam, and, as Mr. Barnaby adds, 'by absolute hugeness,' that the merchant steamers in the North Atlantic trade have obtained their extraordinary qualities of speed, with a comparatively moderate expenditure of power in proportion to displacement. In making comparisons between the Navy and merchant service we are fully sensible that the conditions are not equal, and that the failure to obtain the same speed with the same horse-power in the cruisers designed for general service is due to the special requirements both in respect to the ability to carry sail and armament for which the Admiralty contractors have been called upon to provide. With these explanations we insert tables prepared by Captain Long for his paper, read at the United Service Institution. They give the dimensions of some of the most successful examples of naval architecture for the purposes of commerce, and bring into comparison some distinctive types both of the naval and commercial services. The tables will be found on pages 298, 299. We give on the following page a table of a similar character, borrowed from a nautical periodical.

Captain Long. Tables of dimensions of steamers.

Distinguishing No.	Description of Vessel Date of Launch W., Wood I., Iron S., Steel	Dimensions in Feet					Sail Power		
		Length at L.W.L.	Beam ditto	Mean Load Draught	Displacement	Ditto available for Coals and Cargo	Rig	Sail Area	Coefficient of comparison
1	'La Plata,' W., 1851 [1]	280	37½	20½	4,207	—	—	—	—
2	'Indiana,' I., 1852 [2]	254	38¾	18½	?3,662	—	—	—	—
3	'Alabama,' W., 1862 [3]	230	32	15	1,575	—	Barque	—	—
4	H.M.S. 'Nelson,' 1877 [4]	280	60	24½	7,473	—	Ship	24,770	64·5
5	Cape Mail Steamer, S., 1879	360	43	24	7,240	4,350	Brig	16,990	45·4
6	Steamer A	360	43½	22 27½	5,900 7,900	3,500	„	17,225	46·0
7	French Mail Steamer	393½	44	24	7,593	2,800	3-mast barque.	17,545	45·1
8	Atlantic Mail Steamer, I., 1878	450	45	26	9,300	4,200	4-mast barque.	21,725	49·0
9	Atlantic Mail Steamer 'Britannia'	455	45	23½	8,500	—	„	—	—
10	Australian Mail Steamers, I., 1879	445	46	26	9,400	4,500	„	23,450	52·7
11	H.M.S. 'Iris,' S., 1879	300	46	19¾	3,735	—	Barque	12,704	52·7
12	H.M.S. 'Inconstant,' I., Wood-sheathed, 1868.	337⅓	50¼	23	5,962	—	Ship	26,655	82·8
13	French 1st-class Cruiser 'Tourville,' S. and I., Wood-sheathed.	327	50	22½	5,350	—	„	20,451	66·8
14	H.M.S. 'Volage,' I., Wood-cased, 1869.	270	42	20	3,320	—	„	16,593	74·4
15	French 2nd-class Cruiser 'Villars,' S. and I., Wood-sheathed.[7]	249½	38	15¾	2,232	—	„	13,993	81·8
16	H.M.S. 'Comus,' S. and I., Wood-sheathed, 1878.	225	44	15½	2,383	—	„	13,746	77·3
17	French 3rd-class Cruiser 'Eclaireur.'	254	35½	14¾	1,617	—	Barque	13,519	98·0
18	H.M. King of the Netherlands 'Atjeh.'[8]	262½	41	19	3,129	—	—	17,061	80
19	French Mail Steamer	330	43¾	22½	5,206	1,755	3-mast barque.	18,191	60·5
20	New type, Messrs. Short	280	40	19¾	4,133	2,310	Brig	—	—
21	'Daniel Steinman'	277¾	34½	21	4,030	2,300	—	10,602	41·8
22	'Merkara'	360	37	16¼	3,980	—	—	—	—
23	'Jaroslav,' S. and I., Wood-sheathed, building.[9]	310	41	19½	3,150	—	—	—	—

[1] Consumed 100 tons per diem. Recommended.
[2] Consumed 36 tons per day. Rejected as iron.
[3] Confederate cruiser. Maximum speed ever attained, 13½ knots.
[4] Hull and engines, 4,047 tons; armour, 1,720 tons.

Steam Power							Armament		
Propeller	I.H.P.	$\frac{\text{I.H.P.}}{D^{\frac{2}{3}}}$ {coeffi. for comp.	Speed on Trial	Coal stowed	Distance passable: At full speed	Distance passable: At 10 knots	Can fire ahead	Can fire astern	Can fire abeam
Paddle	1,000 nom.	—	13¼	1,300	3,816 at regular speed.		1 8-inch, 65 cwt.	Proposed 8 32-prs., 42 cwt.	1 8-inch, 65 cwt.
Screw	300 nom.	—	10½ mean.	640	4,284 at mean speed.		Same Scantlings as 'Himalaya.'		
Lifting screws.	300	—	11	All consumed going to Terceira.			1 100-pr.	6 32-prs.	1 8-inch
Twin screws.	6,624	17·3	14	1,200	2,520	3,528 At 12¾	800 lbs.	Projectiles. 1,800 lbs.	800 lbs.
Single screw.	3,156	8·4	13·9	1,250	7,500	11,100 about.			
”	2,704	8·0 mod.	13·8	1,500	10,600	14,400			
”	3,284	8·4	14½	1,100	4,800	?10,000			
”	6,500	14·7	17·3	1,320	4,560[5]	10,000 about.			
”	4,900	11·7	16½	1,200	4,320 at 15 knots.				
”	5,595	12·5	15·54 mean.	1,895	7,350[6]	16,000 about.			
Twin screws.	7,714	32·5	18½	750	1,730	6,800			
Single screw.	7,361	22·4	16½	680	1,504	3,000	2 6½-ton	10 9-inch 12-ton.	2 6½-ton
”	7,363	24·0	16·9	800	2,400	5,000	2 7½-inch	14 5½-inch 4 7½-inch	1 7½-inch
”	4,500	20·0	15·14	420	1,638	2,500			
”	2,500	14·6	15·5	400	2,418	5,000	2 6¼-inch	12 5½-inch	1 6¼-inch
”	2,300	12·9	13	370	2,028	3,600			
”	1,900	13·8	15	210	1,530	3,500			
”	2,269	10·6	14·5	280	1,260	3,000	1 6½-inch	4 6½-inch 4 4¾-inch	1 6½-inch
”	2,786	9·2	14·4	970	4,900	10,000			
”	1,000	3·9	10·0	400	—	3,900			
”	700	2·8	10·9	250	—	4,690			
”	2,000 1,560	— 6·2	13·0 12·0	500	4,488 at 12 knots.				
”	?3,000	?14	?15	—	—	—			

[5] Based on actual service. Greatest mean speed on 2,800-mile passage, 15·95 knots.
[6] Based on actual service.
[7] Can fire three guns each side at 23° from keel. [8] Cost 169,200*l.*
[9] To be armed with two rifled mortars as well as guns.

Name of Ship	Owners	Where built	Year	Dimensions: Length ft.	in.	Breadth ft.	in.	Depth ft.	in.	Tonnage	Horse-power	How propelled
Britannia	Cunard Line	Greenock	1840	230	0	34	5	22	5	1,150	440	Paddles.
Great Britain	Great Western Line	Bristol	1843	274	2	48	2	31	5	3,270	500	Screw.
Asia	Cunard Line	Greenock	1850	268	2	45	2	24	1	2,227	750	Paddles.
Arctic	Collins Line	New York	1850	290	2	45	2	31	5	2,860	1,000	„
Persia	Cunard Line	Glasgow	1855	360	2	45	2	32	5	3,300	900	„
Great Eastern	Great Eastern S.S. Company	Millwall	1858	679	6	82	8	48	2	18,915	1,000 1,600	„ Screw.
Scotia	Cunard Line	Glasgow	1862	379	6	47	8	30	5	3,871	1,000	Paddles.
City of Paris	Inman Line	„	1866	346	6	40	4	26	2	2,651	550	Screw.
City of Brussels	„	„	1869	390	6	40	3	27	1	3,081	600	„
Oceanic	White Star Line	Belfast	1871	420	6	40	9	31	1	3,707	600	„
Britannic	„ „	„	1874	467	6	45	2	33	7	5,004	760	„
City of Berlin	Inman Line	Greenock	1875	520	6	44	2	37	7	5,491	1,000	„

Having given the dimensions of the fastest ships in the mercantile marines, it may be interesting to compare them with the proportions adopted in the case of the 'Iris.' The policy of building that vessel has ceased to be a subject of controversial discussion. It may be defended on the ground that despatch vessels of extreme speed are required to watch an enemy, and convey information of his movements. It may be criticised on the ground that fast merchant steamers offer greater advantages. With their superior length and displacement they can maintain their speed in all conditions of weather, with a degree of regularity quite unattainable in the 'Iris,' and with a conspicuous economy of steam-power. While the load displacement is only 3,700 tons, the 'Iris' is propelled by engines of over 7,750 indicated horse-power. The principal dimensions of the 'Iris' are: length 300 feet, breadth 46 feet, mean load draught 19 ft. 9 in. Comparing these dimensions with large Atlantic passenger steamers of recent types we find in the 'Britannic' length 455 feet, breadth 45 feet, and in the 'City of Berlin' length 488 feet, breadth 44 feet.

Comparative blue-water speed of 'Iris' and Atlantic steamers.

The displacement of the 'Iris,' as it has already been stated, is 3,735 tons, and the indicated horse-power 7,750. The displacement of the 'Britannic' is 8,500 tons, and the indicated horse-power 4,900. The speed of the former at the measured mile is 17·9 knots. The speed of the 'Britannic' on the ocean is 16½ knots. It will be seen that an enormous addition of horse-power is required to drive the 'Iris' one knot and a half faster than the 'Britannic' in smooth water. In ocean-steaming against the winds and the waves which ordinarily prevail in the Atlantic, it would be unreasonable to expect that the 'Iris' could hold her own with the 'Britannic.' In weather of such severity as to reduce the speed of the 'Britannic' to thirteen knots, the 'Iris' would probably be compelled to ease down to less than half the speed of the merchant steamer. The explanation is not far to seek. With one foot more beam, the length of the 'Iris' is only three-fifths that of the 'Britannic.' The 'Britannic' is protected from the stern to abaft the foremast, and from the taffrail to before the mizenmast, with a turtle back of iron plating. The 'Iris' has no such protection, and if driven at a high speed in the teeth of an Atlantic gale would be buried in waves through which the 'Britannic' could force her way in safety.

Comparative speed, 'Iris' and 'Duquesne.'

Comparing the 'Iris' with the 'Duquesne,' we find that the power developed by the engine is rather higher in the English ship, being 7,750 as against 7,340 horse. The speed at the measured mile is 17·9 knots, as against 16·93. The displacement of the French ship

is 5,340 tons, as compared with 3,750 in the 'Iris.' The beam, as it has been already stated, is 50 feet, as against 46 feet in the 'Iris'; the length 327, as compared with 300 feet; the draught of water being the same in both cases. The 'Iris' carries 780 tons. The coal-supply of the 'Duquesne' is 430 tons. The 'Iris,' therefore, although so far inferior in displacement, has a great advantage in coal-endurance, which is due in all probability to the more moderate dimensions of spars and sails.

As ocean despatch vessels, our steamers more efficient.

So far as it is possible it must always be desirable to devote the resources of the dockyards to the construction of ships specially adapted for the war service, and which could not on an emergency be procured by hire or purchase from the mercantile marine. In the case of the 'Iris' a vast expenditure has been incurred to obtain high rate of speed under exceptionally favourable conditions, and without any marked advantages in regard to coal-endurance. As ocean despatch vessels we possess in our mercantile marine several ships far more able than the 'Iris' to maintain a speed of or exceeding sixteen knots, under all conditions of weather, and with a capacity of coal-endurance which the 'Iris' from her inferior dimensions cannot possibly possess. The building of such a ship would therefore seem to have been a proceeding of doubtful expediency. If an 'Iris' had been required in the Navy it would have been desirable to have added considerably to the length, and plans for such a ship were actually prepared by Mr. Barnaby. With such an addition the speed at sea would have been more steadily maintained, and the coal-carrying capacity would have been increased. The evolutionary qualities would have been less satisfactory, but even with the proportions actually adopted the 'Iris' cannot be accepted as a fighting vessel. In an ironclad ship, where an increase of length implies an increase in the area to be protected with armour, and where it is consequently more economical to give speed to the vessel by powerful engines than by fine lines and additional length, the objections to extreme length are far more serious.

Armaments.

Turning from speed and coal-endurance to guns, the French ships are decidedly inferior to the English in broadside armament. On the bow the 'Duquesne' carries three 19 c/m. or 7·8 ton guns, while the 'Raleigh' has one 12-ton gun. The French gun has a range of 2,000 metres, and against unarmoured vessels is not less effective than our 12-ton gun, while it is unnecessary to remark that the chances of hitting a flying enemy are increased in proportion to the number of guns. On the beam the English ship is much superior in weight of metal. By transporting the bow guns to the broadside the num-

ber of the guns is about the same, or fourteen for the 'Shah,' thirteen for the 'Tourville,' and twelve for the 'Raleigh'; but the English ships carry 64-pounder and the French 41-pounder guns. The French officers would prefer a heavier armament. Lieutenant Very considers that, with their present guns, the 'Tourville' class would be a match in a duel for the 'Shah' or the 'Raleigh,' and that all unarmoured ships are alike ineffective against forts and ironclads.

Comparison of the English and French second-class cruisers.

'Active' and 'Volage' and 'Duguay-Trouin.'

The second-class cruisers of the French navy have a conspicuous advantage both in speed and in coal-endurance over the English ships. In the list of second-class cruisers of the English navy are included the 'Rover,' 'Bacchante,' 'Boadicea,' 'Euryalus,' 'Active,' and 'Volage.' Let us compare our earlier ships with a typical example of the French unarmoured fleet. The 'Active' and the 'Volage' have a displacement of 3,080 tons, being 90 tons more than that of the 'Duguay-Trouin.' The length of the 'Volage' is 270 feet, or 20 feet less, the beam 42 feet, or eight inches more, mean draught 21 feet, or four feet more, and indicated horse-power 4,532, or 792 more than the corresponding figures of the French ships. The speed is fifteen knots, or one knot less than that of the 'Duguay-Trouin.' The 'Active' and the 'Volage' cost 126,000*l.* each. The 'Volage' was launched in 1869, and the 'Rover' in 1874. The 'Rover' has a displacement of 3,460 tons, with a length of 280 feet, breadth 43·6 feet, and mean load-draught 20 feet, and 4,969 horse-power. The 'Duguay-Trouin' has a displacement of 3,130 tons, length 290 feet, beam 42·80 feet, mean draught 16 ft. 10½ in., and 3,740 horse-power. The displacement of the 'Rover' is 330 tons greater, while the length is 280 feet, or ten feet less, with one foot less than the French ship. The speed of the 'Duguay-Trouin' is sixteen knots; the speed of the 'Rover' is 14·5 knots. The area of the midship section of the 'Duguay-Trouin' is 575 square feet, the indicated horse-power 3,740. The area of the 'Rover' is 685 square feet, and the horse-power 4,960; being in the one case six, and in the other seven horse-power per square foot of midship section. The 'Duguay-Trouin' has an advantage over the 'Rover' in the number of guns for bow-fire. On the broadside she has two 19 c/m. or 7¾-ton guns, and two 14 c/m. or 46-pounder guns, as against two 6½-ton guns and eight 64-pounders.

'Rover' and 'Duguay-Trouin.'

'Boadicea,' 'Bacchante,' and 'Duguay-Trouin.'

The difference in the proportion of length to breadth is still more remarkable in the case of the 'Euryalus' and the 'Bacchante.' The displacement of these ships is 4,130 tons, length 280 feet, beam 45½ feet, load-draught 22 ft. 2 in., and horse-power 5,400. As compared with the 'Rover,' the 'Euryalus' and the 'Bacchante' have the same length, namely, 280 feet, while they have two feet more beam,

760 tons more displacement, 440 more horse-power, and only half a knot more speed. Their original cost was 222,000*l*. As compared with the 'Duguay-Trouin,' the 'Euryalus' and 'Bacchante' have a length of 280 feet against 290, 45½ feet beam against 42·8 feet, displacement 4,130 against 3,130 tons, and horse-power 5,400 against 3,740. With their much larger dimensions, and far more powerful machinery, our ships steam fifteen knots, the 'Duguay-Trouin' sixteen knots. The latter ship carries 430 tons of coal, and the distance attainable at ten knots is 4,000 miles. The 'Boadicea' carries 574, and 'Bacchante' 500 tons of coal, and the distance attainable at ten knots is 3,020 miles for the 'Boadicea,' and 2,630 for the 'Bacchante.' The area of the midship section of the 'Euryalus' and 'Bacchante' is 785 square feet, and the indicated horse-power 5,400, or roughly, seven horse-power per square foot, as compared with six for the 'Duguay-Trouin.' The comparison of armaments is not given, the English ships having an admitted superiority in this respect. It is to gain these advantages in gun-power that proportions have been accepted less favourable to speed than those of the French ships. It may be repeated once more that these comparisons are not made with a view of showing a deficiency of skill in design on the part of Mr. Barnaby and his able staff; it seems quite superfluous to say that they are perfectly able to furnish the Navy with ships possessing the highest qualities of speed. They have been fettered, however, by requirements as to armament and sail-power, while in France speed under steam has been the primary consideration. Successive Boards of Admiralty are responsible for the policy which has been adopted.

'Comus' and 'La Perouse.'

The vessels of the 'Comus' type are of 2,383 tons, with a length of 225 feet, beam 44 ft. 6 in., and 2,300 horse-power. Their first cost may be estimated at 110,000*l*. Let us compare these vessels with a French ship of corresponding dimensions. The 'La Perouse' has a displacement of 2,200 tons, length 260 feet, beam 37·4 feet, and indicated horse-power 2,500 horse. The speed of the 'La Perouse' is 14·7 as against thirteen knots in the 'Comus.' The 'La Perouse' carries an armament of two 14 c/m. (53 cwt.) or 46-pounder guns in the bow, and eight guns of similar calibre on the broadside. The 'Comus' class have two 6½-ton guns for bow fire, and a broadside of one 6½-ton and six 64-pounder guns.

'Villars' and 'Opal.'

The 'Villars,' another type of the French second-class cruisers, has a displacement of 2,227 tons, with a length of 249 feet, 38 feet beam, and 2,500 horse-power. Comparing this ship with the 'Opal,' we have in the English type a displacement of 1,945 tons against 2,227, length 220 feet against 249, beam 40 feet against 38, and

2,100 horse-power against 2,500. The 'Villars' steams fourteen and three-quarter knots, and carries 400 tons of coal, being a sufficient supply for 4,000 miles at ten knots. The 'Opal' steams barely thirteen knots, and has a coal-capacity of 260 tons. On the bow the 'Opal' carries two 64-pounders; the 'Villars' two 46-pounders. On the broadside the 'Opal' has seven 64-pounders against three 16 c/m. or 5 ton, and five 14 c/m. or 46-pounder guns. In the armament, therefore, the English vessel, though inferior in displacement, the difference being more than 300 tons, exhibits a decided superiority. The weak point of the English ship is her speed. This deficiency in a small ship, intended specially for convoy, blockade, and the capture of privateers, is condemned as a vital fault by Lieutenant Very.

'La Clocheterie.'

When the compiler passed through the China Seas in the 'Sunbeam,' the French had a corvette on the station which in speed and coal-endurance far exceeded any vessel in the British Squadron. The vessel in question, the 'La Clocheterie,' was of 1,943 tons displacement and 1,985 indicated horse-power, and steamed 13·73 knots. The length was 259 feet and beam 35 ft. 9 in. The displacement, therefore, was 177 tons less, the length 39 feet more, the beam 4 ft. 3 in. less, the indicated horse-power 200 less, and the speed one knot greater than that of our own cruisers of the 'gem' class, employed on similar service on the same stations. The area of the midship section of the 'Opal' is 546 square feet, and the indicated horse-power 2,187. The area of the midship section of the 'La Clocheterie' is 430 square feet, and the power 1,985 horse, or four horse-power per square foot in the English, and 4·6 in the French ship. The draught of water of the 'La Clocheterie' was 18 feet. She sailed well, having performed ten and a half knots under sail. The bunkers had a capacity of 300 tons, being a sufficient supply for steaming two months at five knots, and 30 days at eight knots. The armament included ten 14 c/m. breech-loading rifled guns, two *en barbette*, forward and aft, and eight on the broadside. The coal-endurance showed a marked superiority over that of our flagship, the 'Audacious.'

'Alma' and 'General-Admiral.'

The 'Alma' class, from which the French flagship on the China station is selected, carry 300 tons of coal, a supply sufficient for 2,740 miles at ten knots. The Russian armoured cruisers 'General-Admiral' and 'Duke of Edinburgh' carry 1,000 tons, which is equal to 5,900 miles at ten knots.

The importance of making the future corvettes of the 'Comus' class as perfect as possible in all respects may be appreciated from

'Comus' and 'St. Augustin' of the French Trans-atlantique Company.

the fact that we have already six composite and five wood corvettes of this class in the British service. It may be interesting, therefore, to extend this comparison of the corvettes of the 'Comus' class to merchant vessels. The 'St. Augustin' is one of four vessels lately ordered from Messrs. Elder by the Compagnie Générale Transatlantique for their increasing trade between Marseilles and Algeria. The dimensions are: length 316 ft. 6 in., beam 33 ft. 6 in., depth 25 ft. 6 in., displacement 2,480 tons, mean draught 14 ft. 11½ in., and immersed midship section 422 square feet. The speed on the measured mile was 15·35 knots per hour, the engines showing about 2,563 indicated horse-power. Comparing the 'St. Augustin' with the 'Comus,' we have the same displacement, with 87 feet more length, 11 feet less beam, 200 more indicated horse-power, and a superiority of speed of 2·56 knots. The 'St. Augustin' could not be admitted on the Admiralty list, but the necessary improvements might have been introduced without detriment to the speed.

'Rigault de Genouilly' and 'Comus.'

The third-class cruisers in the French Navy are represented by the 'Rigault de Genouilly.' Their displacement is 1,610 tons, length 236 feet, and beam 35·4 feet. They have 1,900 estimated horse-power, and an estimated speed of fifteen knots. They carry 210 tons of coal, and are estimated to steam 3,700 miles at ten knots. With 770 tons less displacement and 550 less horse-power than the 'Comus,' they have an advantage in speed of two knots. The explanation is to be found in the very different dimensions adopted in the two types. The length is 236 feet in the French and 225 feet in the English ship, while the beam is 35·4 feet, as compared with 44·6 feet in the 'Comus.' The areas of the midship sections are 366 square feet in the 'Rigault de Genouilly,' and 611 feet in the 'Comus,' the indicated power being 1,900 in the 'Rigault de Genouilly,' and 2,450 in the 'Comus,' or 5·12 horse for every square foot in the one case and four in the other. As general service cruisers in time of peace the 'gem' class are most useful. Several have not been satisfactory on account of the breaking down of their machinery, but the failures were caused by accepting tenders at the lowest price. As seagoing ships the 'Comus' or the 'Magicienne' class have been highly approved.

'Amazon' and 'Blanche' and 'Rigault de Genouilly.'

We find the same inferiority of speed in our older ships of the same class. The 'Amazon' and 'Blanche' may be compared in point of dimensions with the 'Rigault de Genouilly.' The displacement of the 'Blanche' is 1,699 as against 1,610 tons, length 212 against 236 feet, beam 36 against 35·4 feet, and horse-power 2,158 against 1,900. The speed of the 'Blanche' class ranges from 12·2

to 13·6 knots. The 'Rigault de Genouilly' is estimated to steam fifteen knots. The area of midship section in the 'Blanche' is 434 square feet, and the indicated power 2,158 horse, or five horses for every square foot, as against 5·12 in the 'Rigault de Genouilly.' The 'Blanche' carries a broadside of two 6½-ton and two 64-pounder guns. The 'Rigault de Genouilly' is armed with a broadside of five 14 c/m. or 46-pounder guns. The French ship has a coal-supply of 210 tons, or sufficient for 3,000 miles at ten knots. The 'Blanche' carries coal for eight days at eleven knots, which is equal to a distance of 2,564 miles. We have 14 sloops of the 'Blanche' class.

'Doterel' and 'Chasseur.'

The first-class sloop, as represented in the French service by the 'Chasseur,' has a displacement of 780 tons, length 200 feet, beam 28·5 feet, and 849 horse-power. Our larger vessels, of the 'Doterel' class, have a displacement of 1,124 tons, or 344 tons more than the 'Chasseur.' Their length is 170 feet, or 30 feet less, beam 36 feet, or 7 ft. 7 in. more than that of the 'Chasseur.' They have 1,000 horse-power, being an excess of 150 horse-power over the French vessel. With this advantage in horse-power, and a displacement larger by 344 tons, the 'Doterel' steams eleven and a half knots, and the 'Chasseur' 12·18 knots. Here, again, a superiority in speed is due to the finer lines adopted in the French service. The French sloop carries 110 tons of coal, being a sufficient supply for 3,000 miles at ten knots. The 'Doterel' has a great advantage both in the number and in the calibre of her armament. She carries two 6½-ton guns and four 64-pounders, as against four 14 c/m. or 41-pounder guns.

'Chasseur' and 'Flamingo.'

Comparing the 'Chasseur' with the 'Flamingo,' or the 'Bird' class, the displacement of the former is 780 tons, length 200 feet, and beam 28 ft. 6 in., as against 610 tons displacement, length 157 feet, and beam 29 ft. 6 in. in the English vessel. The French ship has 50 feet more length, and the horse-power is 849 in the French and 750 in the English sloop. The 'Chasseur' steams 12·18 knots, and the 'Flamingo' 11·55 knots. The French sloops have long projecting bows very strongly constructed, and capable of penetrating through the sides of the 'Inflexible.' At full speed one of these small vessels, fairly striking our monster ironclad amidships, would inflict a fatal wound. Every precaution has been taken to render the French despatch vessels of the 'Chasseur' type efficient. They are fitted with watertight bulkheads to prevent their sinking in the event of their losing their 'snouts' after ramming. The internal arrangements are equally perfect, the between decks being extremely lofty and well-ventilated. Our sloops carry one 9-ton and two 6½-ton

guns, against four 14 c/m. or 46-pounder guns in the French ships. Once more we find in the English vessel a decided superiority in armament, and a not less distinct inferiority in speed. In the greater number of cases the inferiority of the French lies not so much in number of guns as in weight of metal. The French are satisfied with light long-range guns, and they attach a higher importance to speed than to an armour-piercing armament for unarmoured vessels.

Gunboats 'Banterer' and 'Crocodile.'

When we come down to the small vessels of the gunboat class, in which it is impossible to preserve the fine and graceful lines so characteristic of the French models in the larger classes, we are no longer at a disadvantage in point of speed. Comparing our 'Banterer' class with the French gunboats of the 'Crocodile' type, we have a displacement of 451 tons and 360 horse-power, as against 451 tons and 457 horse-power in the French gunboat. The 'Crocodile' has a length of 141·7 feet, beam 23·9 feet, and carries 50 tons of coal. The 'Banterer's' length is 125 feet, and beam 23·5 feet, or within a fraction the same as that of the French boats. The area of midship section is 161 feet in the 'Crocodile,' and 199 in the 'Banterer,' the indicated power being 2·5 in the former and 1·8 in the latter. In gunboats speed is less important than armament; but it is interesting to find that under conditions of equality as regards beam and engine-power our vessels steam ten knots, and have thus an advantage of nearly a knot over the French gun-vessels.

Proposed 16-knot steam cruiser and 'Duguay-Trouin.'

In order to bring this examination of the French and English unarmoured cruisers down to the latest date, the design of the fast cruisers which have been commenced at Messrs. Napier's may be compared with the 'Duguay-Trouin,' to which reference has already been made.

Their principal dimensions are as follows:—

	Proposed 16-knot Ship	'Duguay-Trouin'
Displacement . .	3,750 tons	3,126 tons
Coal-supply . .	1,000 tons	430 tons
Speed at measured mile .	16 knots	16 knots
Indicated horse-power .	5,000 knots	3,700 knots
Coal-endurance at ten knots	5,000 tons	4,000 tons
Length . . .	300 feet	293 feet
Beam . . .	46 feet	43 ft. 4 in.

The contract for the new ship is 130,000*l*., or about the same as that of the 'Volage' and 'Active,' of 4,000 indicated horse-power, with a displacement of 3,078 tons.

In view of the rapid increase of fast cruisers in the French Navy, the late Board determined to build three vessels of the same

class. Designs having been called for, the controller submitted two alternative proposals, the one providing for a speed of fifteen knots, with a full spread of canvas, the other providing for a speed of sixteen knots, with a light rig similar to that of the 'Iris' and 'Mercury.'

As a cruiser for the pursuit of such vessels as the mercantile auxiliaries recently purchased for the Russian Navy, and as the representatives in our own fleet of the unarmoured vessels which the French are now and have for some years past been building so much more rapidly than ourselves, the sixteen-knot ship presents conspicuous advantages over the fifteen-knot design.

The additional complement required for the more heavily rigged fifteen-knot ships constitutes a serious objection. It cannot be politic to crowd together large numbers of men in unarmoured ships, exposed to destruction by a single shot. The unarmoured ships will be employed in the pursuit of vessels sent forth to cut up our commerce, and which will neither be heavily armed nor numerously manned. To add to the spread of canvas to such an extent as to involve a considerable increase in the complement, beyond what would be necessary for the purpose of fighting the ship, would appear to be a course which might expose the *personnel* of the Navy to grave and needless danger.

It involves the further disadvantage of an increase of beam and a consequent loss of speed of one knot an hour. Speed being of vital consequence for the protection of commerce, the design for the sixteen-knot ship has been wisely adopted as preferable in every point of view to that for the fifteen-knot ship.

Special ships for training purposes.

All will admit the necessity for providing a sufficient number of ships capable of being handled effectively under sail, and a few iron auxiliary screw ships should be built, capable of being used as cruisers in time of war, but specially adapted for the training service, and comparatively inexpensive. Such vessels would be more satisfactory than mere modifications of a design for a first-class cruiser, all the alterations proposed being distinctly detrimental to the fighting qualities of the ship.

Advantages of special types for special services.

The unarmoured class which has met with most universal favour in the Navy is that represented by the 'Staunch' and 'Blazer.' These craft are of small draught, carry a very heavy armament, can be turned in their own length, and can be safely moved—under due precautions—from port to port. Why have they answered so well? It is because they have been designed for a special purpose, and are not intended to cover innumerable different and even antagonistic objects.

Russian unarmoured vessels.

It may be desirable to extend to the Russian Navy the comparison which has been made, with the aid of Lieutenant Very's report, with the French Navy. The ships recently ordered by the Moscow Committee, under the apprehension of a war with this country, were vessels of moderate armament, but with fine lines and great advantages of speed. According to information recently published in the *American Army and Navy Journal*, the Russian clipper fleet consists of the 'Kreutzer' and 'Djigit,' both at Vladivostock; the 'Jemtchong' at Sveaborg; and the 'Rasboynik,' 'Nayazdnik,' 'Plastoon,' and 'Strelok,' now being completed at Cronstadt. All have been constructed since 1875, and are designed for service in the Pacific. Their principal dimensions are as follows:—length 214 feet, beam 33 feet, depth 14 feet, displacement 1,334 tons, 250 nominal, or 1,500 indicated, horse-power, speed 13 knots, coal-supply for 5·6 days at full speed, armament three 6-inch guns of Krupp construction on a revolving platform on the upper deck, and a number of 4-pdr. carronades. Three very similar corvettes, the 'Vsadnik,' 'Bayan,' and 'Haidamak,' have recently returned to Cronstadt from the Pacific, and are now being fitted out for a second term of service.

'Zabijaka.'

Another ship, the 'Zabijaka,' recently built by Messrs. Cramp of Philadelphia, has a length of 220 feet, or 50 feet more; beam 30 feet, or six feet less; displacement 1,200, or 76 tons more than the 'Doterel.' The horse-power is 225 nominal, or 1,300 effective, as compared with 900 horse in our own vessel. The average speed maintained in the 'Zabijaka,' on the passage from London to Cronstadt, was 13·4 knots, while the measured mile speed of the 'Doterel' is only 11½ knots. The 'Zabijaka' carries 315 tons of coal, a supply sufficient for fourteen days at full speed, during which the ship could cover a distance of 6,000 miles. The armament consists of three 6-ton guns and four rifled 9-pounders. The complement is 125 men, including twelve officers. The 'Zabijaka' underwent a trial on August 21, when the Grand Duke Constantine was on board. With 93 revolutions the speed was fourteen and a half knots. With half-power only a speed of ten knots was easily attained. The cost of this clipper was to have been 275,000 dollars, but fines for deficiency of speed and other causes reduced her price to 153,000 dollars. The 'Zabijaka' is of iron. She is very imperfectly secured by bulkheads. The engines and boilers are above water.

'Rasboynik' and 'Nayazdnik.'

The seven unarmoured cruisers already enumerated as recently built for the Russian Navy may be briefly described. Two vessels of the new class, the 'Rasboynik' and the 'Nayazdnik,' recently visited this country on their way to China. Their dimensions are:—dis-

placement 1,335 tons, length 240 feet, as compared with 170 feet in the 'Doterel,' and beam 30 feet, as compared with 36 feet. It will be observed that the proportions adopted in the Russian service are assimilated rather to those of the French than to those of the English ships of the same class. They are built of iron cased with six inches of wood, on which is fastened copper sheathing. The engines are of 250 nominal, or 1,500 indicated, horse-power, the average speed at the measured mile being 13·115 knots. The armament consists of three steel 6-inch pivot breech-loading guns of the Krupp pattern, and four steel breech-loading broadside guns of 10 centimètres calibre, firing shot of four pounds, and intended to be used as torpedo-guns. The heavy guns fire 160-lb. projectiles. The armament is completed with two machine-guns and a steel breech-loader which can discharge eight to ten shells per minute.

General observations on our policy of armoured ship-building.

We conclude with a few general observations. In our unarmoured classes an attempt has been made to combine in each ship so many qualities that the especial purpose for which they have been built has been lost to view. We wanted fast cruisers to protect our commerce. We built vessels heavily armed and of large displacement, and yet so ill provided with coal that they could hardly steam from one port to another at a moderate speed, while the cost was so great that many repetitions of the design were considered impossible.

In the third-class cruisers of the French Navy, of the 'Rigault de Genouilly' type, of only 1,640 tons displacement, but with an estimated speed of fifteen knots, it has been shown that good speed and great coal-endurance may be obtained in ships of reasonable dimensions and at a moderate cost. To secure such a result the attempt to combine the sailing ship with the steam cruiser must be abandoned.

The views, which it has been endeavoured to recommend by a detailed comparison between the English and French unarmoured ships, were strongly advocated in *Fraser*, in October 1876, in an article on the present condition of the Navy.

***Fraser*, Oct. 1876.**

'To build ships for fast cruisers it is indispensable that the old type of war-vessel should be widely departed from. High speed is an absolute necessity, and to secure that many of the specialities of a fighting ship must be dispensed with. It should be distinctly borne in mind that their most important duty would be to protect English commerce from the privateers or light vessels of war which might be let loose on it, and it is most probable that little fighting would attend such a course.

'An exceptionally high rate of speed is indispensable to a ship

destined to protect commerce, and with this important quality a good stowage must be allied. This is not a difficult problem to solve if these two elements meet with the special attention they deserve, but in combination with a large number of guns it is an impossibility. Such a battery means, we repeat, a cramped engine-space, a numerous crew, and great immersion—three most objectionable points. It is impossible to construct a ship to combine extraordinary speed with great fighting powers, and in this class the latter must be secondary. In place of fourteen guns four would be ample. Two of these should be amidships, and they need not be of large calibre, the remaining two to be heavy pivot guns, and when housed to lie as far from the ends as practicable. Weights placed near these points will impair the steaming or sailing qualities of ships, however fine their lines may be. Neither is it possible to attach much armour without seriously impairing the speed. A belt in the wake of the engines and boilers, with bulkheads forward and aft, would be ample. In addition to the bulkheads of the engine-room a species of collision-bulkhead of armour-plating might be placed at a reasonable distance from the stem, care being taken not to put it in such a position that the momentum of pitching would be large from its weight. Not a pound of armour should be laid on the upper deck. It would be a useless encumbrance, serviceable only to guard against a plunging fire, a fire which these vessels could never be subjected to on the cruising in which they would be engaged. Of course a reasonable amount of sail-power is an absolute necessity, but by a judicious use of steel lightness and strength may be combined in an extraordinary degree. As a general rule it may be assumed that, other things being equal, the speed will increase directly as the length; therefore the length in these vessels certainly ought to be eight times the width. If they be not overburdened with top-hamper there need be no anxiety on account of their stability. Should these proportions be much exceeded, the amount of power required to bring them up to the proposed speed will be so great as to render coaling frequently necessary. This defect will at once reduce their usefulness and bring them to the level of ordinary cruisers. It cannot be too strongly impressed on the constructor that their fighting qualities should be of secondary importance.

'As a protection against ramming, a rib of teak might run from the bluff of the bow to the knuckle of the quarter. Coasting steamers find such a protection of great service amidst the rough handling to which they are subjected. The steering gear is of the utmost importance, and the portion worked by steam should be placed below the water-line.'

Turning to the shipbuilding programme for 1880–81, the largest unarmoured vessels in progress were the 'Mercury,' double-screw steel despatch vessel of 3,735 tons and 7,000 horse-power, armed with ten 64-pdr. guns. Next in order of tonnage followed the three steam cruisers already described, and four corvettes of the 'Comus' class, armed with fourteen 64-pdr. guns. The steam cruisers have a speed of sixteen knots. The 'Comus' class steam thirteen knots. The programme further comprised two despatch vessels, seven composite sloops of the 'Doterel' class, with a speed of eleven and a half knots, five composite gun-vessels of the 'Lapwing' or 'Bird' class, of 774 tons, 750 horse-power, carrying six guns, with a speed of ten and a half knots, eight gun-vessels of the 'Bulldog' class, of 455 tons, 360 horse-power, four guns, and a speed of nine and a half to ten and a half knots, two surveying vessels, two steel gunboats, a mooring lighter, and fifty-five torpedo-boats. In all we had in progress thirty-five unarmoured vessels, exclusive of the torpedo-boats, and three only were equal in speed to the third-class cruisers in the French Navy.

Programme, unarmoured vessels, 1880–81.

The French programme for the reconstruction of the fleet, as settled in 1872, included eight cruisers of 5,310 tons displacement, with a speed of seventeen knots, two of which are completed, eight second-class cruisers of 2,990 tons displacement, with a speed of sixteen knots, eighteen third-class cruisers of 1,610 tons displacement, with a speed of fifteen knots estimated, and certainly exceeding fourteen knots, and eighteen sloops of 780 tons displacement, capable of steaming over twelve knots. They had in progress at the end of 1878 two first-class cruisers, the 'Iphigenie' at Brest, and the 'Naiade' at Toulon, having an estimated speed of fifteen knots; nine cruisers of the second class, of the 'La Perouse' type, having a speed of 14·7 knots; and two first-class gunboats, the 'Aspic' and the 'Vipère;' and, in addition to these, three transports, three sloops, and twelve torpedo-vessels.

French programme of 1872.

The unarmoured vessels in construction in France in 1878.

The German programme includes 10 decked corvettes of the 'Bismarck' type, of 2,856 tons, with a speed of fifteen knots.

German programme.

Our naval requirements can only be determined with reference to the nature of the attack which may be directed against us. Our most recent experiences have shown that our ironclads might have been surrounded in the Eastern waters by a cloud of those torpedo-boats, of which upwards of one hundred were constructed for the Russian Navy in seven months, while our commerce might have been harassed by the attacks of armed merchant steamers. The speed required in our own vessels must of course depend on the

Attacks would be directed against our commerce.

speed of the hostile ships, and the details brought together in the present section will have been sufficient to show that a large proportion of our possible antagonists have a decided advantage over our own ships in the essential quality of speed. We have, therefore, to consider how the deficiency is to be made good. The vessels required for the ordinary duties of the police of the seas, and which are constantly in commission or under repair, must, of course, be provided by building specially for the Navy. For certain stations we must rely, to a great extent, on sail, and must sacrifice other qualities, including speed under steam, in order to carry canvas. This remark will apply in a still larger sense to ships for the training service. For the most part, however, the ordinary service of the Navy can be efficiently performed without imposing such a heavy rig as would be inconsistent with good steaming qualities. We have sacrificed steaming qualities unnecessarily in order to secure the power of carrying sail, and, as Mr. Barnaby has shown, might with advantage adopt the finer lines of the French cruisers. Length is, no doubt, a disadvantage in tacking and wearing, but it is an essential element of speed. In our future designs for the general service of the Navy we should insist on a speed at least equal to the French ships of the same tonnage.

The armaments must be reduced as regards the calibre and weight of the guns. The improvements lately introduced will secure range and armour-piercing power in guns of much lighter calibre than heretofore. We may combine in mixed armaments a few heavy pivot guns with a larger number of light guns on the broadside.

By these modifications no quality essential to an unarmoured vessel will be lost, while additional speed will be gained. We shall be able to secure any speed we may require in a few exceptional vessels by increasing the horse-power and reducing the spars. For reasons which have been fully stated it does not appear politic to build additional ships of the 'Iris' class. Unarmoured ships of extreme speed must necessarily be costly, and at the same time weak as fighting machines. In the emergency of war the Naval Administration of Great Britain will possess resources in the reserve of swift cruisers which it will be their duty to form in the mercantile marine.

In all ships of more than 1,000 tons some protection should be given by armour to the boilers and machinery. The best defence for the hull is to be found in cellular subdivision.

CHAPTER V.—(*Continued*).

UNARMOURED SHIPS.

SECTION V.

Mercantile Auxiliaries.

Inferiority of our unarmoured fleet to the French in speed.

HAVING reviewed and compared our unarmoured vessels with the corresponding types in foreign navies, and especially those to be found in the French service, the conclusion is forced upon us that we are in a position of inferiority in the essential feature of speed. We have, therefore, to consider what steps we ought to take in order to create an unarmoured fleet which we may venture to consider adequate to the task of protecting our commerce. Are we to multiply in our own service vessels of the lightly armed and vulnerable types which have been lately built in France? In adopting this course we shall be building vessels for the navy having nothing to recommend them as fighting ships except their speed; and, if we are looking only to speed, shall we not be following a more statesmanlike policy if we avail ourselves of the admirable vessels to be found in our mercantile marine? It is admitted that we cannot acquiesce in a position of inferiority to the French in the speed of our unarmoured fleet. We are brought, therefore, to one of two alternatives. We must build a sufficient number of vessels for the navy superior to the French in speed, or we must organise a reserve of mercantile auxiliaries. Our cruisers, with a speed not exceeding thirteen knots, would afford no protection to our commerce, if we were harassed by the attacks of faster vessels. We may have an advantage in cruising qualities under canvas. We may have a far more powerful armament; but, unless we can overtake an enemy, we cannot turn to account those other advantages, for which the essential quality of superiority in speed under steam has been sacrificed.

Our special resources in the Mercantile Marine.

In France no disposition is manifested to engage in maritime enterprise. The fisheries thrive, but the shipping interest generally is languishing to decay. The maintenance of the ocean-going steam tonnage under the French flag is chiefly due to the interven-

tion of the Government, which has created a considerable steam fleet by the artificial process of large subsidies for mail services. Quite recently the legislature has given its sanction to a lavish scheme of subsidies and subventions to merchant shipping. We are in a very different position in this country. In no other field of commercial enterprise have we achieved such marked success as in our shipping. We should turn our advantages to account for the reinforcement of our navy. Our merchant navy is conspicuously superior just where the Royal Navy is weak. It possesses many ships, which far exceed not only the unarmoured vessels in our own navy, but the great majority of those in the French navy, both in speed and coal-endurance. If we build such a fleet of swift unarmoured cruisers for the navy, as we certainly ought to have, in order to be prepared to cope with the French unarmoured fleet, and if we insist on combining in our vessels the same weight of armament and the same capability of cruising under canvas, which we have always held to be necessary to make a satisfactory man-of-war, we must be prepared for a very serious expenditure. A high-speed mail steamer can be built for 35*l.* a ton, while the composite 'gem' class cost over 70*l.* a ton, the frigates 90*l.* a ton and upwards, and even the wooden-built 'gem' corvettes cost over 60*l.* a ton.

Vulnerability of all unarmoured ships.

It is unnecessary to remark that unarmoured ships, however costly, will still be in a high degree vulnerable. They cannot be accepted as a serious addition to our fighting strength. If, on the other hand, we accept more fragile types, with little to recommend them except their great speed under steam, we are building for the navy what we could have obtained on far more favourable terms by entering into combination with the merchant service. We are needlessly weakening our fighting navy. We are expending on a non-combatant *matériel* resources which might have been more effectively applied to the creation of powerful fighting ships of a type which would not have been created outside the navy for commercial purposes. Impressed with the force of these considerations, it will be worth our while to examine with some care the means at our command in the mercantile marine.

Progress of the question.

Some years ago, at the request of the Council of the Institute of Naval Architects and the Committee of the United Service Institution, I read two papers on the employment of the mercantile marine as an auxiliary to the navy. In suggesting that our merchant shipping was a source of weakness in a certain sense, as offering a large vulnerable area to the attack of the enemy, but that it might, on the other hand, be made, under proper organisation, a source of strength,

I was broaching what at that time was regarded as a somewhat novel and impracticable idea. The question has made progress since those days. It is now discussed in a different spirit, and with a more favourable appreciation.

It is now proposed to give a brief review of the resources of our merchant navy for self-defence. Some may think that we are so secure that preparation for the emergency of war is superfluous; but, as it was wisely said by Lord Palmerston, 'to imagine that we are safe from invasion now without precautions, because hitherto we have prevented it by precautions, is the greatest of all possible absurdities.' Splendid and powerful as our ships may be, the navy must inevitably be deficient in time of peace in point of numbers. For the tremendous exigencies of war, the fleet must be supplemented and expanded by equipping and arming our ocean mail steamers. General view of our resources.

The resources of our mercantile marine are highly appreciated by naval administrators, and that too in countries where the ocean steam service has not attained to the development it has reached in this country. 'There is,' says the Secretary of the United States Navy, in his report of 1869, 'another element of defence in time of danger, perhaps as effective as any other, available to wise and liberal statesmanship. . . . Such means would be at hand if we had lines of ocean-going steamers established. There are now running from New York, Boston, and Baltimore to Europe, over sixty powerful screw steamers, any of which could be quickly converted into an efficient and powerful ship of war, capable of carrying full sail-power and keeping the seas for any length of time. Had our mercantile marine possessed such lines at the breaking out of the late war, we might have quickly closed every Southern port. A comparatively small force of this kind, appropriately armed, and let loose on the ocean under the command of bold and intelligent officers, would be a dangerous foe to the commerce of any country. Our own ships were substantially driven from the seas by two or three roughly-equipped vessels, much inferior in power to those of which I have spoken.' Importance of the Mercantile Marine as a reserve of strength to the Navy. Report of Secretary U.S N., 1869.

In the *Congressional Globe* report of the proceedings in the United States Congress of December 4, 1872, evidence is quoted, which had recently been given by Admiral Porter before the Committee of Congress on the decline of commerce. He had been asked the following question: 'I understand you to say that if, at the commencement of the late war, we had had thirty steamers like those running to New York from Europe, they would have been as Evidence of Admiral Porter. Committee of Congress, 1872.

efficient as our entire navy?' He replied: 'Twice as efficient. I say that without hesitation. The ships we had could catch nothing. We never had a vessel that could run down a blockade-runner during the whole war, except the "Vanderbilt" and two others. Our ironclads are only suitable for harbour defence. In case of war with Great Britain or France, our powers would be exerted in cutting up their commerce. Great Britain could not stand a war six months with the fleet of ships we could send out after her vessels. They would break her up, root and branch, and that kind of warfare would be more likely to bring about peace than fighting with ironclads or heavy war-vessels.'

Admiral Porter, U.S.N., 1874.

Admiral Porter repeated the same statement in his annual report to the Secretary of the United States Navy, for the year 1874. 'It is only,' he wrote, 'by destroying the commerce of a great nation that we could bring her to terms. One vessel like the "Alabama" roaming the ocean, sinking and destroying, would do more to bring about peace than a dozen unwieldly ironclads cruising in search of an enemy of like character. For this reason I would recommend that we should build up a fleet of swift wooden cruisers, of at least 1,200 tons, with the heaviest batteries, and a speed of not less than fourteen knots.'

Report of Secretary U.S.N., 1877.

The policy of giving liberal subsidies for the conveyance of mails has been repeatedly recommended by the secretaries of the United States Navy. In the report issued in 1877, it was pointed out that England and France had gained a conspicuous superiority over the United States, as ocean-carriers, on the coasts of South America, China, Japan, and Australia, and had even snatched the trade of a considerable portion of the American Continent out of their hands:—'Of the exports from China, more than three times as much go to Great Britain as to the United States. With the imports the difference is greater still. Australia exports 50,000,000*l.* a year, and the imports are nearly as large as the exports. Nearly the whole of the entire trade is with England.' Our success is attributed to the large subsidies paid by the English Government to its steam lines. These views will scarcely find acceptance with those who recognise in the magnificent development of our trade and shipping the spontaneous action of commercial enterprise.

Subsidies paid by the French Government.

Where the same resources and the same energetic spirit are not found, it may indeed be necessary to adopt another policy. Impressed with this conviction, the French have granted large subsidies for the conveyance of mails, and have by these means created an important reserve of mercantile auxiliaries. A proposal has recently

been adopted by the legislature for granting a considerable bonus to merchant shipping. The original proposal was to limit the subvention to a round sum of 3,200,000*l.* It has now been determined to allow 60 francs a ton on the gross tonnage built of iron or steel vessels, 40 francs a ton for composite vessels, and 12 francs per kilogramme for steam machinery, and to give 1 franc 50 centimes per ton for every thousand miles traversed by ships during the first year after the date of launching. The premium is to be reduced by 7 centimes yearly for wooden or composite ships, and by 5 centimes for iron ships. This premium is to be increased by 15 per cent. for iron ships built according to plans previously approved by the Minister of Marine. The ships are to be at the disposal of the Government for war service.

Comte de Gueydon.

The expenditure of the French Government upon their war navy bears a large proportion to the interests they have at stake in their mercantile marine. But even the French navy is dependent on mercantile auxiliaries for expansion in time of war. In an address delivered to the Société des Études Maritimes et Coloniales, Admiral the Comte de Gueydon spoke in terms of enthusiasm of the merchant service, as at once the parent and the offspring of the fighting navy, as the main source of its power, and yet dependent on its protection from every danger which threatens.

Admiral Pothuau.

In his evidence before the French Commission on the depressed condition of the shipping interests, the Minister of Marine, Admiral Pothuau, stated that he looked to the merchant service as an essential reserve for the fleet, and as the source from which not only seamen, but ships, must be drawn. Like Admiral Porter, whose official advice has been quoted, the ablest officers in the French service have abandoned the idea of contending, to use the words of Baron Grivel, 'with the 20,000 guns of our fighting navy.' Their aim would be to pursue the 50,000 merchant ships which are continually engaged in transporting the wealth of England over the watery plain. They believe that the French fleet could carry on for an indefinite period a privateering war, and that the immediate result would be a rise in the rates of insurance, and the transfer of the great carrying business of the sea from British ships to foreign flags. They assume that the great source of our national prosperity would thus be destroyed, and that a state of commercial and financial suffering would ensue, of which the sagacious and far-seeing men who direct the Government of England would soon grow weary. While the great fleets sent forth by Napoleon were vanquished in those signal victories which have illustrated the naval history of England with undying fame, the

Baron Grivel.

privateering expeditions of the French were attended with considerable success. Between February 1, 1793, and December 31, 1795, they captured 2,099 English merchantmen, while their own losses in the same period were limited to 319 ships.

'If,' says Baron Grivel, 'we had to compel such an enemy as the United States to make peace, we should have to commission our best frigates, and to supplement them with a certain number of "Alabamas;" and this policy would entail much less financial pressure than the construction of armoured cruisers.'

German opinions.

Turning from France to Germany, the *Marine Verordnungs Blatt* recommends that the authorities at the Admiralty should enter into an agreement with the principal steamship companies for the payment of certain sums, in consideration of which the owners should undertake to adapt the construction of their ships to the exigencies of maritime war.

Comparison of the strength of France and England in fast unarmoured cruisers.

Having shown that on the outbreak of war our enemies would direct their most strenuous efforts to the destruction of our trade, let us proceed to consider the means at our disposal for its protection.

Declaration of Paris.

By the Declaration of Paris—

I. Privateering is, and remains, abolished:

II. The neutral flag covers enemy's goods, with the exception of contraband of war:

III. Neutral goods, with the exception of contraband of war, are not liable to capture under enemy's flag:

IV. Blockades, in order to be binding, must be effective: that is to say, maintained by a force sufficient really to prevent access to the coast of the enemy.

Is it to our interest to seek to abrogate the treaty into which we have entered?

The reply to this question may be given in the following observations, taken from an article which appeared in the *Edinburgh Review* of April, 1878, on the naval strength of England:—

'The agreement into which we and other European states have entered by the Declaration of Paris has secured our sea-borne commerce from many of the dangers to which in former wars it lay exposed. That portion of it which may not be transferred to neutral flags will have nothing to fear from privateers. When our naval officers and the mercantile world are fully aware of the real effect of the Declaration, it will be as popular as a couple of years ago it seemed to be the reverse. Prize-money, which may be hoped for from the capture of defenceless merchant-ships, fell but in scanty portions to

the crews of the great fleets which fought on "the first of June" at the Nile, or at Trafalgar. Whilst the privateersman and the independent cruiser grew wealthy on the spoils of war, the majority of His Majesty's officers and men were worn out with watching Villeneuve or Gantheaume; and their hard-won captures were divided into too many "shares" to form of themselves an adequate reward for the hardships and risks of a long blockade.'

Our maritime trade being infinitely more extensive than that of any other nation, the area of vulnerability which we expose to attack is infinitely larger than theirs. On the other hand, our superiority in actual preparation for war to any probable, I might almost say possible, combination of nations against us is incontestable; while our unrivalled resources for the construction of the most powerful ships would give us the means of adding to our existing fleet with a rapidity which could not be equalled abroad. If, therefore, any future naval contest, in which we may be involved, is confined to the fighting ships on either side and to naval operations directed against fortified places, we shall be the greatest gainers by the adoption of the new rule of international law.

It is to be remembered, as it has been pointed out by Sir Spencer Robinson, that the Declaration of Paris, though highly favourable to the general interests of maritime commerce, affords no protection and could not reasonably give protection to contraband goods. Coal, provisions, gunpowder, and all other munitions of war will be exposed to capture. May we not go further? Is not the only security, that the engagement to respect private property in neutral bottoms will be observed, to be found in the power of every nation to give protection to its own shipping?

It is by the operations of war properly so called that naval war must be carried on. The duty of the Navy will therefore be principally confined to keeping open the great ocean highways, and to preserving freedom of access to the great coaling stations which stud them. For the protection of commerce we must rely on our mercantile auxiliaries.

Fighting power of the merchant ships.

Admirals Elliott and Ryder.

In the independent report of Admirals Elliott and Ryder as members of the Committee on Designs, the fighting power of the merchant ship was not regarded as contemptible even in an encounter with an ironclad. They express the conviction that a few swift merchant steamers, armed with one or more of the heaviest guns, with extemporised raft protection, and their magazines and boilers specially protected, would be capable of making a formidable attack on one of our lightly-armed ironclads.

At the annual meeting of the Royal United Service Institution

Sir Cooper Key. in 1880, it was stated by the chairman, Sir Cooper Key, 'that the Admiralty were quite alive to the importance of taking up merchant steamers in time of war; and if they had provision for arming those steamers in the event of war, and some twenty or thirty could be so armed at our dockyards, it would be a matter of great importance.'

Admiral Hoskins. In the discussion on Mr. Donald Currie's paper, read at the United Service Institution on March 5, 1880, on 'The Adaptation of Ocean Steamers to War Purposes,' Admiral Hoskins said that 'armed merchant steamers would be able to protect themselves against the class of vessels which it had been proposed to send against them.'

Admiral Sir William Hall. Admiral Sir William Hall, in a recent pamphlet, has recommended that 'a certain supervision should be exercised over the future building of steamers, with the view of ensuring for them some little increased strength, sufficient to enable them to carry one, two, or more rifled guns. Vessels thus armed could not be employed against ironclads; it would be against a flotilla of transports that they would be most useful.'

Nautical Magazine. The *Nautical Magazine* has given its hearty approval to the policy of supplementing the Navy with armed steamers. 'There can be no doubt that there are the materials in the registered steam tonnage of this country for a supplemental organisation of this nature, such as no other State can furnish forth. The heavier class of ironclads can never be employed by this or by any other country as seagoing vessels; the protection of colonies and of commerce will be committed to armour-plated frigates, with heavy armaments, and to gunboats; to such a fleet a number of armed steamers would be of the utmost importance and assistance, and would well repay any expense which the State might incur in their hiring and equipment. The students of our maritime history will be at no loss to light on instances where the merchant ships of England have done good service against the enemy. Times have changed, no doubt, and a great revolution has been wrought in the British mercantile marine, since two of our East Indiamen, engaged in the Indian Ocean, gave a good account of their opponents. But the spirit which prompted that deed of gallantry survives in our seamen and their commanders in both the Royal and the Merchant Services, and whenever the opportunity arrives it will once more be displayed.'

Broad Arrow. In an article which appeared in its issue of March 13, 1880, the *Broad Arrow* recommends that, we should enlist some of our swiftest ocean vessels in the defence of the mercantile marine. 'The suggestion is Mr. Currie's, and nothing more valuable has been made for many a day. His idea is that a certain number of swift-steaming

merchant ships should be conditionally retained in the service of the country by means of an annual subsidy; that they should retain on board a certain number of men in the Royal Naval Reserve, with four leading gunners to instruct the crew; and that at certain specified stations—he mentioned several—there should be permanently established a sufficient number of men of the Royal Marine Artillery and light infantry with guns, ammunition, torpedoes, and other appliances ready to arm the retained vessels, the moment they could put in for that purpose after the declaration of war. If this idea were adopted and developed upon each main commercial route in the world, there would be speedily placed a number of swift armoured gunships capable of affording protection to our commerce and of preventing any serious raids. The Cape mail steamers would find at Simon's Bay all they wanted. Vancouver's Island would supply Pacific steamers, and Hong Kong the Chinese steamers. Halifax, Sydney, and Bermuda would be other and convenient centres. But it would be necessary to provide these places with graving docks. There is no graving dock at Simon's Bay or the other places we have named, with perhaps the exception of Hong Kong and Melbourne. Yet in 1865 the Colonial Docks Loan Act clearly recognised the importance of this provision. The preamble clearly sets forth that, with a view to secure accommodation for vessels of the Royal Navy in British possessions abroad, it is expedient to authorise loans in aid of the formation there of docks of dimensions greater than would be requisite for commercial or other private purposes.' Loans at a low rate of interest should be granted up to a certain amount out of the Consolidated Fund. Hong Kong, Whampoa, and Table Bay, so far as we know, are the only places where these powers have been put in operation.

'When war seemed imminent a few years ago, the Admiralty obtained a return of vessels of the merchant navy that could be so used. Plans and information were furnished. It was said that thirty fast-steaming vessels were to be armed and converted into gunships. "All these inquiries," remarked Mr.[1] Donald Currie, "the information obtained, the arguments advanced, and the opinions given, had resulted in no practical issue." The then current idea was to have armed them at home as auxiliaries to the Royal Navy. Mr. Currie's idea of arming them abroad is infinitely better. There is not, in fact, any reason why selection and armour should not proceed upon a mature, a deliberate plan, known only to the Admiralty and the steamship owners, and coming into operation

[1] Now Sir Donald Currie, K.C.M.G.

within a few weeks of the beginning of war. The difficulty lies in the shipment and storage of the necessary war material. And it is here where the beginning must be made, just as it is in the provision of the necessary armed coaling stations that we must seek to render efficient any important addition to the swift-steaming frigates of the Royal Navy.

'Indeed, the new demand must take the form of an organised naval defence co-extensive with the British Empire. This is even more important than an organised military defence, necessary as that may be in certain eventualities. The Royal Commission authorised last year ought to render us efficient aid. "It was instructed to inquire into the condition and sufficiency of the means, both naval and military, provided for the defence of the more important seaports within our colonial possessions and their dependencies, and to report as to the stations required for coaling, refitting, or repairing men-of-war, and for the protection of the commerce of the colonies with the United Kingdom, with each other, and with foreign countries." When this report is made we hope no party politics will come into play. We cannot develop the Royal Navy as recommended by Sir Spencer Robinson, or select, subsidise, and arm the cream of the Merchant Navy, as suggested by Mr. Donald Currie, until we have roused ourselves from our present routine and lethargy.'

Saturday Review.

Powerful journals, quite uninfluenced by professional bias, have lent a not less hearty support to the proposal for creating a reserve of ships in the mercantile marine. The following article appeared in the *Saturday Review* of June 22, 1878:—

'In ordinary time of peace shipbuilders may, of course, construct vessels of war for Foreign Governments, and may put guns on board, and it is hardly necessary to point out how many ships have been built in our ports for the navies of other countries. Whether, if hostilities between England and Russia were imminent, it would be the duty of the Government of Washington to put a stop to the equipment in American harbours of Russian vessels which were being armed in obvious anticipation of almost immediate hostilities, is a question which we do not propose at present to consider; but certainly it seems extremely likely that no measures would be taken until war had been declared. Some cruisers then, of which the preparation had been continued up to the very last moment, might be put to sea before war began, and, receiving their full complement of men from vessels sent to meet them, might be perfectly ready to prey on our merchant ships. After the commencement of hostilities

it may fairly be assumed that the American Government would use all the means at their disposal to carry out the provisions of the Treaty of Washington, but it is difficult to believe that they would be able to prevent the occasional escape from some of their numerous ports of vessels which would receive their armament after leaving harbour. Our merchantmen would, therefore, be exposed to a certain amount of danger; danger by no means so great, it is true, as would appear from the excited statements of Russian journalists, but still sufficiently serious to deserve consideration. The question is, how these corsairs could be most quickly cleared from off the face of the ocean.

'Our men-of-war would, of course, do much; but it is doubtful whether there could possibly be enough of them to do all that would be required to exterminate these pirates, going forth not to fight but to plunder. A large number of ships of moderate armament, but of very great speed, would be required to sweep all the tracks on which the hostile cruisers were lurking, and to watch those ports and parts of the coast from which it might be thought likely that their supplies would be obtained. Vessels admirably adapted for this kind of work there are in our own service, but not so many as would probably be required; and to keep a host of them constantly ready for equipment would entail vast expense. Fortunately, however, it is not necessary that there should be a large reserve of ships of this sort, if only measures are taken for adding to the Navy, in case of need, a sufficient number of the great merchant steamers, which are in some respects admirably fitted for the work of chasing down piratical vessels, such as have been described. In respect of speed, which would be all-important, no ships in the world equal the huge steamers of the Transatlantic and other lines; and it would appear that a certain proportion of them are fit to be converted into men-of-war. The Admiralty has indeed already considered the subject, and, under the direction of the Department of Naval Con struction, surveys have recently been held on a considerable number of steamships, to ascertain how far they are suited for use in war. From what is known, however, of the scheme of the Admiralty for the employment of these vessels, it hardly seems to have been well conceived, and is apparently open to certain objections which are stated in an article in the *Nautical Magazine*, written by Mr. John Burns, a gentleman well qualified to speak with authority on this subject. According to him "the plan of the Admiralty, briefly stated, is embraced in what is termed a 'select list,' under which it is proposed to include merchant steamers which would

meet certain requirements in the direction of increased bulkheads and watertight compartments, with the object of rendering ships less vulnerable in the event of being struck by shot or shell." With regard to this, Mr. Burns observes that no recompense beyond the official imprimatur is offered to shipowners for making their ships fit to be placed on this list, and that, as in most cases alterations would be necessary, considerable expense would have to be incurred in order to have a vessel placed on the proposed register, without the certainty of any return whatever. He also states that many of the great steamship companies would find that a certain number of their vessels were fit to be placed on the list, but that others, through no fault in their construction, but owing to the nature of the service for which they were intended, were not; and that it would be very disadvantageous for a company to place some of its ships on a public list from which others, perhaps the greater number, would be excluded. Mr. Burns further points out that a probable consequence of the publication of such a list would be to enable the owners of the vessels placed on it to combine for the purpose of raising the rates of hire in the event of a war; and he finally condemns the Admiralty plan as "nebulous," and quite inadequate for bringing about the desired result of strengthening the Naval power of the country by the acquisition of a number of the most powerful merchant steamers.

'Perhaps the scheme does not deserve so sweeping a censure. Whatever may be the objections to the proposed register, it is clear that the recent surveys must have enabled the Admiralty to ascertain what steamers now belonging to the merchant service could be made fit for warfare, and that the information thus obtained might have enabled the authorities to take very prompt measures had war been declared. At the same time, there can be little doubt that a more systematic and carefully considered plan than that put forward is required if the Admiralty is to be able to strengthen the Navy at any time, by adding to it some of the most powerful merchant steamers; and Mr. Burns makes some proposals with regard to this matter which, though not so clearly stated as might be wished, are certainly well worthy of consideration. He says it would not be practicable to deal with the general body of shipowners, and that "a satisfactory system could only be matured and carried into effect by suitable arrangements being made with companies owning large fleets of well-equipped vessels," as these companies "possess facilities bearing upon shore accommodation, official discipline among the crews, and other important appointments," which would be "invaluable to the nation,

were they called into requisition by the Government, in the event of war or other emergency." What he has, therefore, to propose is apparently that there should be a reserve of ships formed from the fleets of the great companies, and, in addition of course to the present Naval Reserve, a special reserve of men, consisting of seamen in the employment of the companies, who would be trained to the use of arms and go through gunnery drill on board vessels of the Royal Navy, stationed at the respective home ports of the companies. The Admiralty would have the right, in the event of war, of purchasing or chartering the ships, "at a rate of hire to be mutually agreed on," *i.e.*, of course to be agreed on before the ships were taken into the reserve, and the companies would undertake, in the event of war, to release the men from all engagements to them, so that they might be employed in the Queen's service. In return, the companies would receive annual payments from the Government.

'As has been said, the suggestions of Mr. Burns are not very clearly stated. A part of his project is to combine the establishment of a reserve of ships with a considerable increase in the number of postal steamers, and to substitute the annual payments for the present subsidies; but this portion of his plan is insufficiently explained. One of the objections which he makes to the list proposed by the Admiralty, namely, that the companies would be unwilling to condemn by inference those of their ships which were not placed on it, applies also to the plan of a reserve, and he does not suggest any means by which this difficulty could be got over. He also fails to give any idea as to the features of construction which might be expected to mark all vessels forming the Reserve, not saying whether it would be practicable to have ships fit to be immediately converted into men-of-war, or merely to have ships which would be made suitable for warfare with a moderate amount of alteration. Despite some obscurity in statement, however, there can be no doubt that his scheme is well worthy of attention, for it seems highly probable that the adoption of a plan based to some extent on what he suggests would enable the Government to utilise, in the event of war, the huge and powerful steamers which our merchant fleet possesses. These vessels might form an auxiliary naval force of great value, and none could be better adapted for the work of chasing down the piratical cruisers which, in spite of all due vigilance, would probably succeed in escaping from neutral ports to prey on the commerce of Great Britain.'

Passing from individual opinions to more general considerations, the introduction of the torpedo into naval warfare has furnished us with a weapon which can be used as effectively by a merchant

Torpedoes can be used as effectively from a merchant ship as a war ship.

Lieutenant Chetchensnowitch.

steamer as by a ship specially built for war. An article appeared in the *Revue Maritime* of February, 1880, containing the translation of a paper on torpedo-warfare, from the pen of a Russian officer, Lieutenant Chetchensnowitch. The writer specially insists on the important part the torpedo-boat is destined to play in naval engagements. He commends the English Admiralty for having added the 'Hecla' to the fleet, as a special vessel for the purpose of carrying torpedo-boats. He refers to the arrangements which had been improvised in the armed merchant steamers 'Grand Duke Constantine' and 'Vladimir,' one of which carried four and the other two torpedo-boats. It was with these torpedo-boats that all the night attacks on the Turkish ironclads were made. The writer recommends that all the boats of fighting ships should be, as far as possible, provided with steam power, and capable of being used as torpedo-boats. He believes that the 'Huascar' would not have ventured to ram the Chilian corvette the 'Esmeralda,' and that the 'Independencia' would not have ventured to pursue the 'Covadonga,' if they had been defended by three or four torpedo-boats.

Admiral Scott.

The suggestions of the Russian writer as to the means of converting merchant steamers into formidable vessels of war, by an equipment of torpedo-boats, had been anticipated in a paper read by Mr. Barnaby at the Institute of Naval Architects, and by Admiral Scott in a paper read at the United Service Institution. Admiral Scott explained how light gigs might be armed with the spar torpedo. If the ships fired off a little powder, to mark the direction in which they were going, the boats might dash in and give a good account of the enemy. Every large merchant ship might carry guns and torpedo-launches. Admiral Scott entertains a high opinion of the Congreve rockets, and recommends that they should be supplied to mercantile auxiliaries.

Captain Long, R.N.

As a general summary of the state of opinion out of doors on the adaptability of merchant steamers for auxiliary cruisers, I give the following extract from Captain Long's paper read at the United Service Institution in May, 1880:—

'While both the "navy" and "mercantile" fleets were built of wood, the first-class merchant ship was armed during war and fought successfully on many occasions. In 1853, when iron steamers were rapidly superseding wooden ones, a joint Admiralty and Ordnance committee sat to consider the suitability of merchant steamers for war. They reported that iron vessels were unfit for war, and selected sixteen out of ninety-one vessels inspected by them as suitable for the reception of a defensive armament to enable them to act as

auxiliaries to the Navy in war time. A Treasury committee, however, in the same year reported "that no expense should be incurred for the sake of giving a military character to the postal vessels," and henceforward all reference to such a character disappeared from the contracts.

'In what respect does the naval position of to-day differ from that of 1853? On the offensive side guns have increased in weight and power. Two weapons, easily portable by merchant ships, have been introduced, the ram and torpedo. On the defensive side our "men-of-war" of the unarmoured type are now largely dependent on water-tight compartments and coal armour, and are principally constructed of iron and steel. These improvements have likewise been applied to merchant ships.

'The most serious objection to the use of merchant steamers for war has always been the exposure of the engines and boilers to hostile shot. As soon as experiment had demonstrated the capacity of coal, with iron plates ⅜-inch thick inserted loosely, to stop shot and localise the effect of bursting shell, this objection was in great part removed. The experiment of 1878 proves that an energy of about 87 tons per inch of the shot's circumference is insufficient to perforate 11 feet of bunker, with three loose plates spaced 2 ft. 10 in. apart, and that shells with large bursting charges are equally inefficacious.

'It does not show what energy would suffice for perforation, nor the probable effect of a broadside of shells. In passing, I observe that it seems possible that horizontal bars or tubes connecting the loose plates, and thus transmitting the shock of impact to a larger surface of loose coal, might render this kind of protection even more efficacious.

'As regards mobility, only first-class cruisers equal in speed the steamers of the Atlantic and Australian lines; the latter also possess greater coal-endurance. On the other hand, "men-of-war" have greater sail-power, and their sheathing enables them to keep the sea without docking for a far longer time than an iron steamer.

'Merchant steamers in their normal condition are incapable of standing a broadside on their central portion; but, by similar arrangements to those introduced into Her Majesty's ship "Iris" and other war-ships, they may be made as satisfactory in that respect as unarmoured sheathless men of war.'

Mr. Barnaby, Institute of Naval Architects, 1877.

Mr. Barnaby, the Chief Constructor of the Navy, has thoroughly examined this question. In his paper read at the Institute of Naval Architects on March 22, 1877, he explained that 'merchant steamers might be so strengthened and armed as to become not only capable

of defending themselves, and attacking armed ships not regularly built for war, but they might also act as useful auxiliaries in all important naval operations. They could be rapidly and effectively defended by armour against end-on fire, and be fitted with a ram and with two 64-pounder guns on the bow. Where ships had been originally constructed with a view to the possibility of their being required for war purposes, an efficient broadside of 64-pounder guns and six-inch armour screens between decks could easily be introduced. The equally fast unarmoured ship of war or privateer would not, and the slower armoured ship could not, attack them.'

Looking at naval warfare from the point of view of the Constructor, Mr. Barnaby divided the defensive operations into five classes:

'I. Self-protection on the high seas against merchant ships converted into rovers.

'II. The patrol of the highways of commerce for the capture of rovers.

'III. Clearing the offing of important harbours.

'IV. Convoying.

'V. The protection of harbours.'

Mr. Barnaby considered that the fast armed merchant ship could perform the duties of self-protection and patrol without the support of ships of war, while in the other operations they could take a useful part as auxiliaries :—

'The ironclad ship will, as a rule, be slower and have less coal-endurance than the first-class unarmoured or lightly armoured ship. The ironclad ship will, therefore, be unable to force the first-class unarmoured or lightly armoured ship to engage her.

'In duels between fast unarmoured or lightly armoured steamships, the ship with most guns will generally be the victor.

'Since the merchant ships cannot mount numerous guns, they will, even when armed, find the modern regular ship of war almost always their victor in single combat.

'It follows from this that fast unarmoured or lightly armoured ships of war must be of great consequence to a navy against which armed merchant ships may be employed by an enemy.

'The speed with which fast steamships can in any weather bear down at night upon slower steamships and sailing ships, and the terrible nature of the attack they can make upon such ships with shells, the ram, and the spar torpedo, will make it impossible to convoy successfully sailing ships and slow steamships, in face of the attack of even unarmoured ships, provided they are fast and efficiently armed.

'The successful convoy of sailing ships and slow steamships in numbers, in face of the attack of fast armed steamships, is impossible.

'The inferences I would draw are—

'1. That the merchant ship, which was at one time the equal of the ship of war, gradually lost its place.

'2. That the extension of delicate machinery in the ship of war, and the perfection of the explosive missiles with which it may be attacked, have been gradually bringing the two kinds of ships again together.

'3. That the appreciation of this fact on the part of the shipowners should produce gradually a still closer approximation, so far as it can be made consistently with success in commercial pursuits.

'4. The appreciation of it on the part of the Government might bring about such an arrangement as would secure for the State the services of all suitable vessels in the event of war, and prevent them from passing into the hands of our enemies.

'5. The possibility of forming efficient colonial contingents to the Imperial naval forces for colonial defence becomes less remote.'

Sir Spencer Robinson.

These views found a powerful supporter in Admiral Sir Spencer Robinson. In the course of the discussion on Mr. Barnaby's paper, he said:—

'If merchant ships can be got to take care of themselves, we shall have overcome the very great difficulty of providing the enormous number of men of war required to protect such a mercantile navy as we possess.

'Mr. Barnaby has put before you a plan by which, with very trifling alterations, some of the very best classes of steamships could be adapted to carry guns. I specially allude to those splendid ships which pass between the United States and England—those ships which have very great speed and very large coal-carrying powers, far exceeding the coal-carrying capacity you can manage to give to any unarmoured man-of-war. They could be made capable of carrying such an armament as would protect them from attacks of vessels of a similar class to themselves. The principal risks of serious attacks to our commerce would not be incurred through the action of men-of-war.'

Sir Frederick Grey.

In the same discussion, Admiral the Hon. Sir Frederick Grey spoke as follows: 'Mr. Samuda seems to deprecate the idea of trusting to our merchant ships at all in case of war. Now, having been at the Admiralty, and having felt the difficulty of providing even in peace time the force necessary to fulfil the various duties devolving

on our ships of war, I think it would be utterly impossible for the navy alone to provide sufficient protection for our merchant ships in time of war. I believe that the merchant ships of England, if strengthened and fitted as proposed by Mr. Barnaby, might be made very useful. I do not say that they would take the place of men-of-war, but they might be made most useful as auxiliaries; and if it should be found difficult to strengthen them sufficiently to carry the formidable weapon, which can be used so effectually by a merchant steamer as Mr. Barnaby has proposed, it must not be forgotten that a new element of offensive warfare has lately been introduced in the torpedo. Many of our fast steamers, if fitted for torpedoes, might, I believe, do good service against an enemy.'

Mr. Barnaby.

Mr. Barnaby, in the course of his reply, said: 'I never came before this Institution with a graver sense of responsibility. I should not have brought the question to your notice if I had not thought it out thoroughly for many months, and if I had not had the opportunity of ascertaining the condition of hundreds of the best merchant ships of this country.

'With regard to some of the matters that have been referred to, they can be disposed of very quickly. As to whether the ships are strong enough to bear the guns that I have talked about, namely, two 64-pounder guns at the bow, I may observe that a 64-pounder weighs complete something like five tons. It will be quite obvious that in an iron ship, even supposing she has not as many beams as would ordinarily be put to support a gun, there are plenty of ways in which, by putting carlings under the beams and pillars under the carlings, you can support the weight of the gun, and I do not think that could cause a difficulty to anyone.'

Comparison of the merchant steamers in the Atlantic trade with the 'Comus.'

The large vessels of our mercantile marine are at least as well adapted for conversion into cruisers for the protection of commerce as the trading steamers of other nations are adapted for conversion into privateers. For such a service speed and coal-carrying capacity are essential qualities, which are possessed in a remarkable degree by the fine steamers employed in the North Atlantic trade.

In his pamphlet on the state of the navy, published in 1878, Mr. Watt makes a comparison between the 'Comus' and a merchant steamer built, at an approximately equal cost, for the Pacific Steam Navigation Company, in which he shows the conspicuous superiority of the merchant steamer in the important quality of coal-endurance. The 'Comus' has a speed at the measured mile of thirteen knots, with a consumption of 59 tons per day. She carries 270 tons, and the blue-water speed is 11 knots. Her coal-supply would suffice for nine

days. The cost of the 'Comus' is 123,000*l.* The 'Corcovado,' built by Mr. Laird for the Pacific Company, at a cost of 120,000*l.*, carries 900 tons of coal and 2,000 tons of cargo. Her blue-water speed is 13 knots, and she carries coal for 45 days, as compared with the nine days' endurance of the 'Comus.' If the object of the 'Comus' class be to catch such ships as the 'Corcovado,' when fitted as privateers, it is quite clear that the object will not be attained.

The late Mr. Lindsay, in his *History of Merchant Shipping*, gave the average passages of the principal lines of ocean steamers between Liverpool and New York. Mr. Lindsay.

The distance from Queenstown to Sandy Hook is 2,777 miles, and it was performed in the years 1873 and 1874, outwards and homewards, by the steamers of the White Star, Cunard, and Inman lines, at the average speed shown in the following table:—

Line	Outwards				Homewards			
	1873		1874		1873		1874	
	Sailings	Average time	Sailings	Average time	Sailings	Average time	Sailings	Average time
		D. H. M.		D. H. M.		D. H. M.		D. H. M.
White Star	47	9 19 48	50	9 22 53	47	8 22 39	50	8 20 42
Cunard .	52	10 16 54	52	10 16 54	53	9 7 59	52	9 5 46
Inman .	50	10 22 4	51	10 22 1	52	10 0 3	51	9 10 50

The fastest passages have hitherto been made by steamers of the White Star line, their speed having been maintained not only in exceptionally fine weather, but in the storms and tempests which sweep across the Atlantic at all seasons of the year. The average passages of the 'Britannic' in 1876 were, outwards, 7 days 18 hours 22 minutes, and homewards, 7 days 20 hours 53 minutes. In April 1877, the 'Germanic,' going westward, logged 410 knots in a day of 24 hours 35 minutes, which is at the rate of $19\frac{1}{4}$ statute miles per hour; and the same vessel, coming eastward in October, logged 394 knots in a day of 23 hours 26 minutes, which is at the rate of $19\frac{3}{8}$ statute miles an hour. Over 400 knots have been several times run by these steamers and the Inman line 'City of Berlin' in a day. White Star line.

The 'Arizona,' of 5,150 tons, built at the Fairfield Works for the Guion line, has actually surpassed the remarkable performances just recorded. She left Queenstown for New York on June 1, 1879, at 12.30 P.M., and arrived at New York on June 8, at 6 P.M., American time, being the fastest passage on record. The distances run each 24 hours in nautical miles were respectively 391, 398, 379, 393, 391, 380, 381, and 130, to time of arrival. The return run to 'Arizona.'

Queenstown from New York was made in seven days and nine hours. The 'Arizona's' second run to New York against strong head gales was done in eight days three hours and three minutes. She returned to Queenstown in seven days eight hours and six minutes.

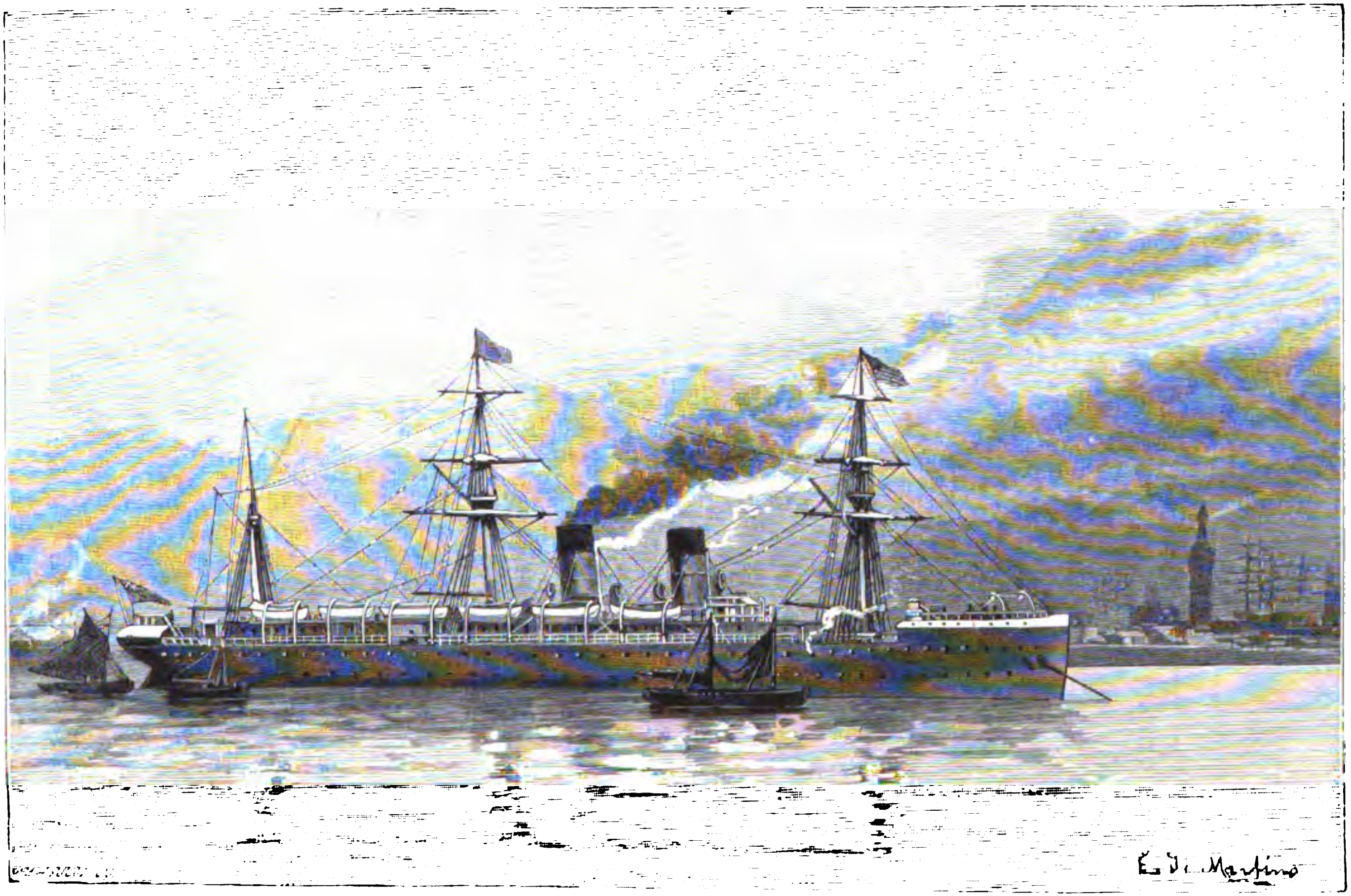
Having given these examples of the remarkable capabilities of the 'Arizona' as an ocean steamer, the following description, which appeared in *Engineering*, in its issue of December 5, 1879, will be read with interest:—

'The "Arizona" is 450·2 feet long by 45·4 feet beam and 35·7 feet depth of hold, with a gross tonnage of 5,147. An idea of the strength of the "Arizona's" bow may be gathered from the following facts. The stem is of solid wrought iron 9 inches by $5\frac{1}{2}$ inches. The plating, which is $\frac{12}{16}$ inch and $\frac{13}{16}$ inch thick on alternate strakes, is at the bow $\frac{9}{16}$ inch and $\frac{10}{16}$ inch thick alternately. There are two iron decks extending the whole length, besides other strengthening at the bow in the way of frames, stringers, and breast-hooks. The collision bulkhead is $\frac{7}{16}$th of an inch thick, and about its rigidity and watertightness there can be no doubt after the test it has been put to. That test was made in a recent collision with an iceberg off the coast of Newfoundland. The vessel, whilst steaming 14 knots an hour at night, ran at full speed against the iceberg. The bows were utterly crushed up for a length of 26 feet at the upper part, the fracture extending to about 14 feet below the water-line. Taking the "Arizona" at a displacement roughly of 9,000 tons, moving at a speed of 24 feet per second, the energy of the blow would amount to about 80,000 foot-tons; or, supposing all the work to be absorbed by the ship, it would represent a resistance of something like 3,000 tons for every foot of the bow crushed up, a force sufficient to cause rupture in 150 square inches of iron if uniformly distributed.

'There is no reason to doubt that at the higher speed of 16 knots the ship would have equally well withstood the effects of the collision. According to a calculation by Captain Long, "at 16 knots the blow represents a total kinetic energy of over 102,000 foot-tons, which is equal to the shock from four 80-ton guns striking simultaneously."' Captain Long remarks that it will probably be conceded that a far lighter blow would suffice to cut any unarmoured ship in half.

Deficiency of merchant steamers in evolutionary qualities.

The power to ram or avoid being rammed depends, however, on manœuvring power, in which merchant steamers are exceedingly deficient. That deficiency is so great that Captain Long is of opinion that the 'Arizona,' if threatened with the ram by the 'Thunderer,' a



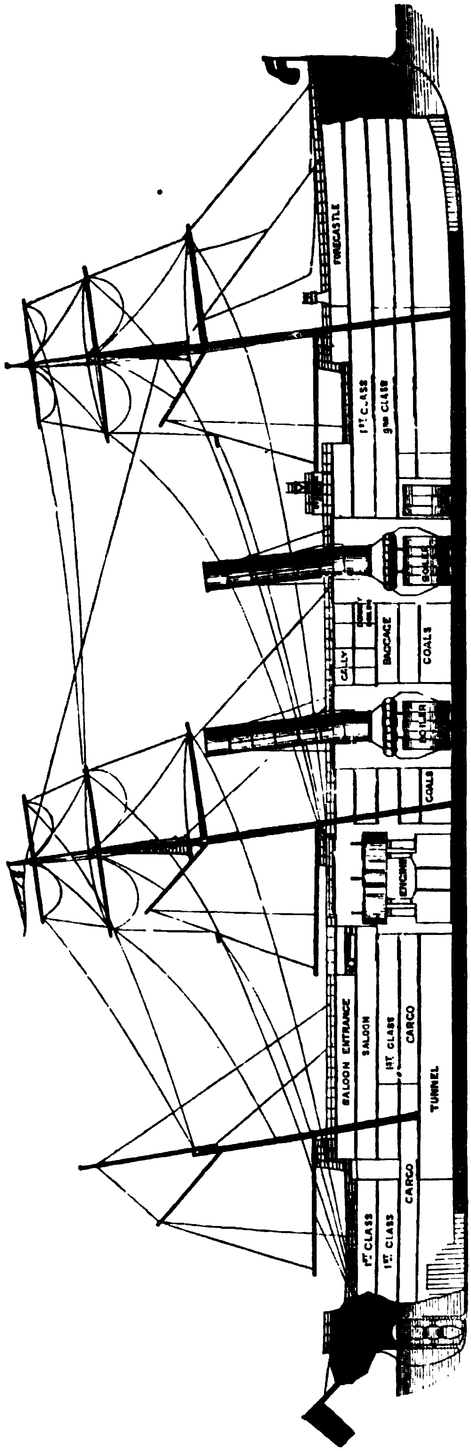
SERVIA.

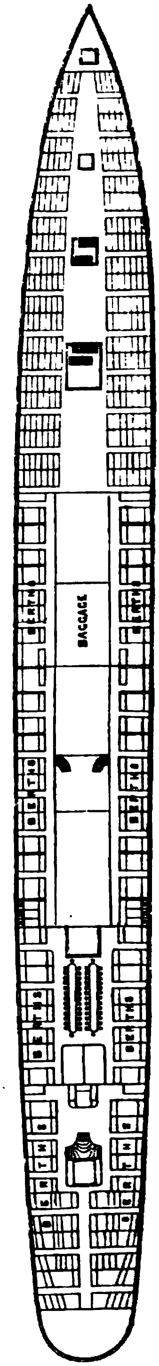
ship of only 285 feet in length, would be compelled to turn the stern to the enemy while he was at least a mile off. The 'Arizona' would, however, in retreat be able to use the gun and the mortar on equal terms with the pursuer, and would have great advantage in the use of the Whitehead or towing torpedo.

The Cunard steamship 'Servia.'

The 'Servia,' the latest addition to the Cunard fleet, is another noble example of the advance of naval architecture in its application to mercantile purposes. The following description is taken from the *Engineer* of March 4, 1881:—'The rapidity with which the dimensions of vessels built for the mercantile service have increased in recent years has been remarkable, and such as to outstrip all former conceptions as to size and driving power. Within the past two or three years Messrs. Elder and Co., of Glasgow, constructed the "Arizona," 5,147 tons, and 1,200 horse-power; the "Orient," 5,386 tons; and the "Austral," 5,500 tons, the two latter for the Orient line; and likewise the "Alaska," for the Guion Line, 6,250 tons. The "City of Berlin," built by another firm, has a tonnage of 5,491, her length being 488 feet. Each of these vessels was regarded at the time she was put into the water as exceedingly large; but they are left far behind by the "Servia," which was launched recently from the shipbuilding yard of Messrs. James and George Thomson, Clydebank, Glasgow. The "Servia" has been constructed to the order of the Cunard Company, Limited, for their Royal Mail service between Liverpool and the United States. The "Servia" is constructed of steel, but is of much greater dimensions. As regards length and tonnage she exceeds all other merchant ships hitherto built, whilst in the matter of engine-power she will surpass anything afloat. The dimensions of the "Servia" are:—length over all, 530 feet; breadth, 52 feet; depth, 40 feet; and tonnage, 8,500. She is constructed with a double bottom on the longitudinal bracket system, and she will carry 1,000 tons of water ballast. Her cargo-capacity will be 6,500 tons, with 1,800 tons of coal. The machinery consists of three cylinder compound surface condensing engines, one cylinder being 72 inches, and the other two each 100 inches in diameter, with a stroke of piston of 6 ft. 6 in., and it is anticipated that the indicated horse-power will be 10,500. Steam will be furnished by seven boilers, one single and six double-ended, all made of steel, with corrugated furnaces thirty-nine in number. The weight of the propeller-shaft is 26½ tons, and the propeller, boss, and blades, which are made of Vickers' steel, weigh 38 tons. It may further be stated here that the anchor davits area 8 inches, and the chain cable pipe 22 inches in

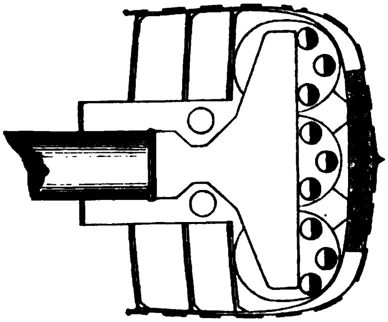
Figs. 107 to 111.



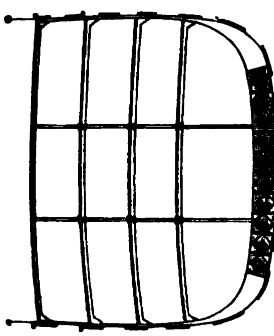


PLAN OF MAIN DECK.

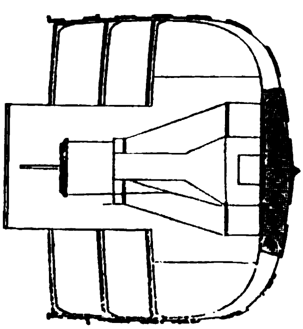
diameter. The " Servia " is to all intents and purposes a five-decker, having four decks and a promenade ; the latter, which is reserved for the passengers, being very large and spacious. The fore part of the promenade contains the steam steering-gear, captain's room, and flying bridge. On the upper deck forward is the forecastle, while behind are the light towers for signalling. The captain's and officers' sleeping apartments adjoin the midship-house, and next to the engine skylight there is a smoking-room, 30 feet long by 22 feet wide, which can be entered either from the deck-house or the cabins below. Near the after deck-house is the ladies' drawing-room, a magnificent apartment with access from the deck, and also leading abaft into the music-room, the dimensions of which are 50 feet by 22 feet. Behind the music-room is the grand staircase, leading to the main saloon, and the cabins below on the main and lower decks. The great saloon is 74 feet long, and 49 feet wide, having a clear height under beams of 8 ft. 6 in., and it affords sitting accommodation for 350 persons. The panelling and upholstery of the



SECTION SHOWING BOILERS.



MIDSHIP SECTION.



SECTION THROUGH ENGINE-ROOM.

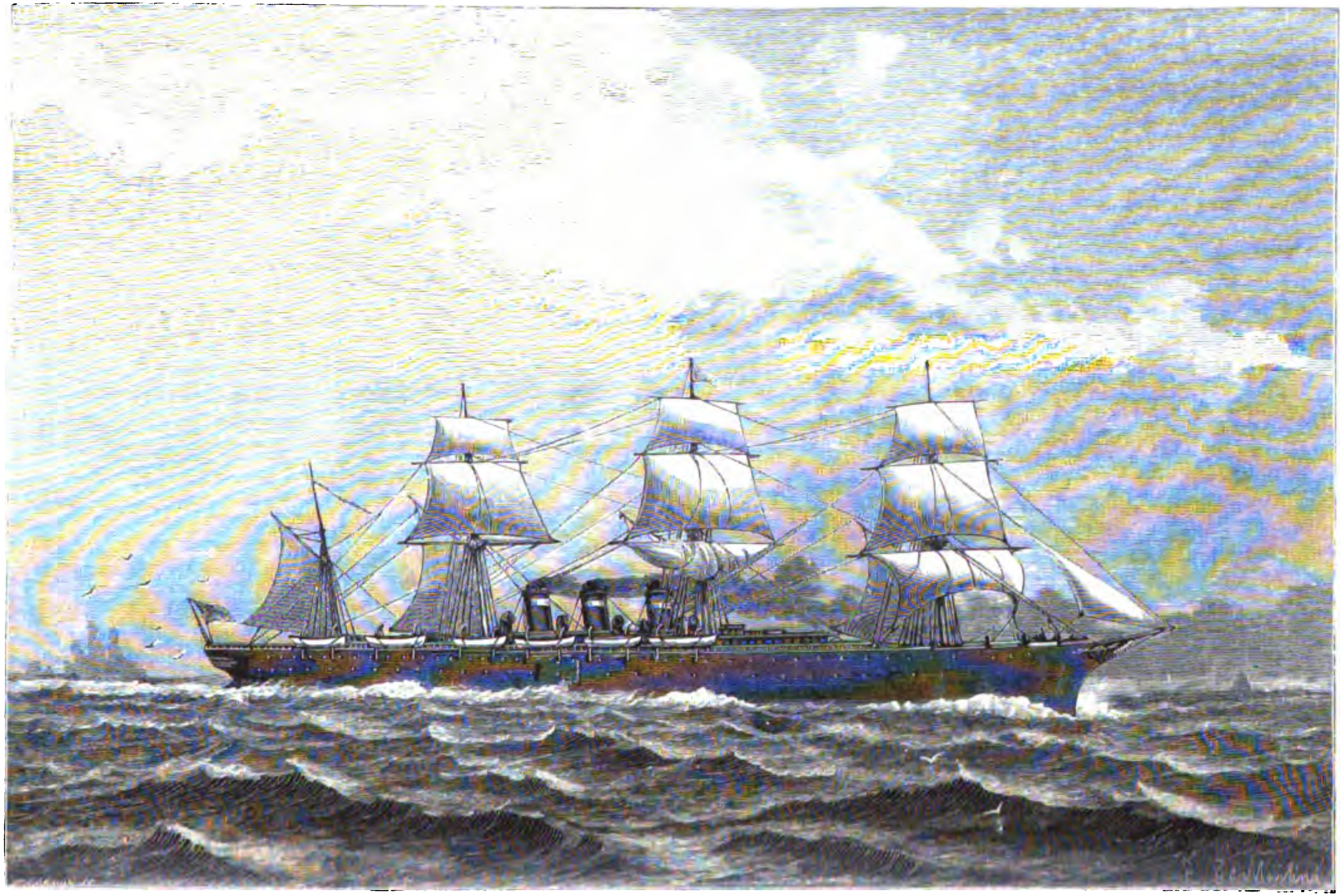
THE CUNARD STEAMER 'SERVIA.'

saloon, and indeed of all the apartments, are very fine. There are 58 state rooms in the vessel, and accommodation for 450 first-class and 600 steerage passengers, besides a crew of 200 officers and men. The ship will carry twelve fully-equipped lifeboats. Built according to the Admiralty requirements for war purposes, the "Servia" is divided into nine watertight portions, a special feature being the arrangement of the watertight doors, which, in case of accident, can be shut from the upper deck in a few seconds. All the frames and beams of the ship have been riveted by Twedell's hydraulic riveter, as was also the keel, which consists of five thicknesses, the total thickness being 6¾ inches. Three of the decks are of steel, the upper covered with yellow pine, and the second and lower decks with teak. To give them the power of resisting heavy seas all the deck-houses and fittings are of iron, and strongly riveted to the steel decks beneath. The "Servia" has three masts, which will carry a good spread of canvas. Great attention will be paid to her furnishings, and she will be provided with the newest and best appliances for steering, ventilation, heating, and other purposes.

'We are glad to see that the value of ample pumping power is now fully recognised by the owners of our great steamship lines. The "Servia" is fitted with three of Messrs. John and Henry Gwynne's direct-acting centrifugal pumping engines, two of which are capable of discharging 11,000 gallons of water per minute each; one of them is sufficient to circulate the water in the condenser, the other being held in reserve. They are so arranged that either engine may work either pump, or quite independently of each other as circumstances require; if necessary both engines can pump from the bilge. The third pumping engine will do the ordinary work of the ship and pump from the ballast tanks and bilge; it is capable of discharging 1,800 gallons of water per minute to a height of 40 feet. All the Cunard steamers, it may be noted, are fitted with Gwynne's pumping engines in a similar manner. The "Garth Castle," and the "Drummond Castle," of Donald Currie and Co.'s line, recently launched, are also fitted with them.

'It may be of interest to state that, including the "Servia," the Cunard Company have at present 30,000 tons of shipping in course of construction on the Clyde. Messrs. Thomson are building the "Aurania," 7,000 tons, and the "Pavonia," 5,000 tons, for the Cunard line; and Messrs. Barclay, Curle and Co., of Glasgow, are building the "Alligator," "Dromedary," and "Gorilla," and Messrs. Blackwood and Gordon, of Port Glasgow, the "Lizard" and "Locust," for the Belfast Line.

'Some remarks made by Mr. John Burns, of the Cunard Company,



CITY OF ROME.

in a speech on this occasion are of considerable interest. There was, he said, a great gulf between the "Britannia," which started on her first voyage more than forty years ago, and the "Servia," and the comparison showed the prodigious steps that had been taken in marine architecture. The "Britannia" measured 1,139 tons, with a cargo capacity of 225 tons, and steamed 8¼ knots an hour, whereas the "Servia" measured 8,500 tons, and would attain, it was believed, a speed of 17½ knots an hour.'

The Inman has long been engaged, as a rival to the Cunard Company, in the same grand field of enterprise. The *Times* of June 15, 1881, contains a description of the last addition to the fleet of the Inman Company:—'The steamship "City of Rome," built by the Barrow Shipbuilding Company for the Inman Line, and intended for the service between Liverpool and New York, was launched on June 14, 1881, at Barrow. She is the largest steamship in the world, except the "Great Eastern." Her dimensions are:—length, 586 feet; breadth, extreme, 52 ft. 3 in.; depth of hold, 37 feet; tonnage, 8,826 tons; horse-power, indicated, 10,000. The distinctive type of the Inman Line has not been departed from in respect of the perhaps old-fashioned but still handsome profile, with clipper bow, figure-head, and bowsprit. The figure-head is a full-length figure of one of the Roman Cæsars, in the imperial purple. The vessel is to be rigged with four masts; and here again the handsome full ship rig of the Inman Line has been adhered to, with the addition of the fore and aft rigged jigger-mast, rendered necessary by the enormous length of the vessel. She will have three funnels, each painted with the company's white band. A point calling for special notice is the large number of separate compartments formed by the watertight bulkheads, each extending to the main deck. The largest of these compartments are only about 60 feet long, and supposing that from collision or other cause one of these was filled with water, the trim of the vessel would not be materially affected. In regard to speed, it has been decided to adhere to the single-screw arrangement, and to adopt a propeller 24 feet in diameter, driven by three sets of inverted "tandem" engines, working on three cranks disposed at an angle of 120 degrees with one another. The engines are intended to work constantly at 8,000 indicated horse-power, although they are capable of developing 10,000 horse-power indicated.'

'City of Rome.'

The 'Servia' and the 'City of Rome' are noble examples of the fleet of mercantile auxiliaries which might be added to the regular force of the British Navy. Their great length is a serious defect.

The power of turning quickly is an essential quality in a fighting ship. In a vessel intended for the pursuit of privateers nothing will compensate for deficiency of speed.

Coal-endurance of merchant steamers.

As an example of the power of endurance of steam machinery under competent management, the recent voyages of steamers to the Australian colonies are equally remarkable. The outward voyages are made round the Cape of Good Hope; the homeward, through the Red Sea and the Suez Canal.

Totals for the round voyage between Plymouth and Sydney, after deductions are made for the canal and the distance between London and Plymouth, are :—

Distance in knots	24,561
Average speed per hour in knots	12
Total consumption of coal in tons	4,268
Consumption of coal per mile in cwts.	3·48

Messrs. John Elder and Co. are building for the Orient Line two powerful steamers, of 5,500 tons burthen and 7,500 indicated horse-power. Their average speed will be sixteen knots, and they will make the passage to Australia *viâ* the Suez canal in 32 days.

The 'Lusitania,' of the Pacific Steam Navigation Company, has lately made the passage to and from Australia in 40 days each way. The 'Lusitania' was 32 days under steam, without stopping, from St. Vincent to Melbourne. On her return voyage she ran through the tropics to Suez in 26 days, with only twelve hours' detention at Aden. Such endurance in a steamer on a long voyage, making an average speed of 320 miles per day, involves a remarkable combination of efficiency both in machinery and management.

The 'Orient.'

The 'Orient,' recently completed on the Clyde for the Australian service, is not only the largest vessel which the Glasgow yards have turned out, but is only surpassed in size among passenger vessels by the 'Great Eastern,' which was built in London, and the 'City of Berlin,' constructed at Greenock. She thus adds another to the list of about half a dozen merchant vessels in the world which exceed 5,000 tons register. The 'Orient' has been built by Messrs. John Elder and Co. She has been equipped beyond the requirements of her class, 100 A1, the highest at Lloyd's, and has satisfied Government inspection as regards her defence by means of watertight compartments and coal bunkers, so that she would be available, if requisitioned for war service, as a cruiser or troop ship. The coal-bunkers are so placed as to protect the engines, while they carry coal enough for steaming at full speed for forty days. The ship could not be sunk by the penetration of less than three of her watertight

compartments. The 'Orient' has three iron decks, and is divided into thirteen watertight compartments by bulkheads, while, as a security against fire from the lower to the main deck, she is divided into six compartments by five fire-proof bulkheads, fitted with fire-proof doors. She carries eight large boats, four of which are fitted as life boats. The lower deck will, if required, accommodate 1,500 troops, and the orlop deck 300 to 400 horses.

Capabilities of British shipbuilding and engineering works.

While we have in our merchant service not a few examples of naval architecture of unrivalled excellence, the tonnage of our sea-going steamers far exceeds that of all other countries, and the ship-building industry abroad is certainly not carried on with the sustained activity which is so remarkable in this country.

It has been truly said by M. Bertin, in an article contributed to the *Revue Maritime*: 'La puissance d'une marine est moins dans son matériel à flot que dans l'outillage des arsenaux et la puissance de production des chantiers.' Our great industrial establishments have come to the aid of the Government on every occasion when their assistance has been necessary. In 1854, in the course of a single winter, the late Mr. Penn supplied 120 sets of 60 horse-power engines for the gunboats which Sir Charles Napier demanded for the operations proposed in the Baltic. During the year 1880 ten steamers of large tonnage, and capable of steaming more than 15 knots, were ordered in this country by the Compagnie Générale Trans-Atlantique. It was stipulated that they were to be delivered in less than six months, and no difficulty was experienced in accomplishing this unparalleled feat in expeditious shipbuilding.

The capabilities of an ingenious and spirited people to create the *matériel* of war were never more conspicuously displayed than in the civil war in America. The South had nothing but the trees standing in remote forests, and the coal and iron hidden deep beneath the soil. The bolts and fastenings were made of the lightning-conductors taken from the ruins of Charleston, and yet the Southern shipbuilders succeeded in producing armoured floating batteries. The North, with greater resources, performed still more wonderful feats. Mr. Ericson's first monitor was built in less than one hundred days, at a cost of 55,000*l*.

If we were engaged in war, and the resources of our shipbuilding yards were applied exclusively to the construction of fighting vessels, we should, in twelve months, be able to create an overwhelming fleet. At the Elswick works, 1,500 men are employed in making guns for every foreign Government. In this establishment the British Government possesses another Woolwich. In marine steam machinery

we stand at the head of the maritime nations. 'All the recent improvements,' said Admiral Porter, in his report of 1870, 'were made on the Clyde and Mersey, where giant strides are taking place in the construction of machinery for war and for the merchant service.' The United States have seven regularly established naval yards, but only four of these are capable of fitting out more than two or three vessels at a time, and in the seven navy-yards there are but three dry docks. In this most important feature their entire resources are inferior to those of Messrs. Laird.

Coal armour. The recent experiments with coal armour tend to raise the value of merchant steamers as auxiliaries to the navy. Mr. Barnaby has publicly stated that no amount of resistance an armour-plate could show had given him so much satisfaction as he had experienced from the excellent results obtained from a combination of fuel and thin loose iron sheets. 'Coal armour and torpedoes together have given the fast merchant shipping of England a significance in warfare wholly new. In the place of being helpless wards to be defended, they become active combatants, a strength instead of an embarrassment.'

Mr. Barnaby's speech was fully discussed in the *Broad Arrow* of April 26, 1879:—

Broad Arrow. 'Such a statement as the foregoing, proceeding from an authority like Mr. Barnaby, is in the highest degree reassuring to all who have ever entertained fears for the safety of our merchant shipping and carrying trade in time of war.

'In coal armour we have the nearest approach hitherto attained to the ideal so long looked for of a truly economical protection. Armour-plates are a helpless inert burden, always carried about by a vessel at great cost for the sake of the protection so afforded. But the coals employed for armour are the coals required to propel the vessel. They form part of her necessary freight. The only extra weight is in the thin iron plates, and that is a matter too small for consideration. It is not pretended that coals are capable of taking the place of thick armour on the sides of our first-rate ships; but as a protection against such projectiles as are discharged from unarmoured cruisers, or to which such vessels are exposed, the coal armour appears to be all that could be desired or expected. With such a simple means at hand for the protection of the vital parts of merchant steamers, we should think that the Government would now take active steps towards the appropriation of these vessels for naval reserve purposes, such as was advocated by Mr. Brassey, M.P., at Birkenhead a short time since. We do not share in that gentle-

man's fears respecting the probable consequences of a war to our merchant shipping; but we, nevertheless, consider the subject of sufficient importance to warrant the Government in giving it serious attention. We shall be very pleased to find that, as a result of the recent experiments on the qualities of coal as a mode of protection against shell, their lordships decide upon creating a mercantile cruiser reserve, composed of such of our ocean steamships as have the necessary speed and are constructed with proper bulkheads. The only addition which these vessels will need consists in their armament, magazines, deck-strengthening, and the temporary side-bunkers for protective purposes. Properly organised and armed, manned by trained crews, and protected in the way we have described, these vessels might be despatched to any part of the world, and be confidently depended upon to defend themselves against the enemy's cruisers, and protect the portion of our merchant shipping engaged in their regular trade. Whatever may be the character of the danger to which our commerce is exposed in the absence of such an organised reserve, there can be no doubt that its existence in time of war would relieve the Royal Navy of such duties as the protection of commerce, and leave the latter free to perform services for which its ships are more peculiarly intended and adapted.'

Thin armour; its value as a protection.

The value of armour-protection of the very limited thickness of from $4\frac{1}{2}$ to $2\frac{1}{2}$ inches was shown in the engagement between the 'Shah' and the 'Huascar.' The latter, although hulled eighty times, received no serious damage. Armour could be introduced in merchant steamers to a limited extent without materially interfering with their stowage. Lieutenant Haye has suggested, in his able essay, that in all cruisers of sufficient size a curved armoured deck should be introduced under the gun-deck, extending from abaft the engines to before the boilers, and touching the ship's side well under water, the space between the armour and gun-deck being filled with reserve coal. The curved armour deck has also been proposed by Captain Scott.

Lieutenant Haye.

War fleet of United States.

Modern history affords numerous examples of the expansion of a small war navy into a formidable force by the conversion of merchant steamers into auxiliary cruisers. In a paper on 'Facts connected with Naval Operations during the Civil War in the United States,' read at the United Service Institution on May 24, 1878, it is stated by Admiral Hamilton, C.B., that the North commenced the war with a fleet consisting of 42 vessels, steam and sail, carrying 550 guns, manned by 7,600 sailors and marines. It was at once seen that this force was totally inadequate to maintain a blockade of over

3,000 miles of coast, to provide for the wants of the army, and to obtain command of the inland waters. The number was increased in December 1861 to 264; in December 1862 to 427; in December 1863 to 588; and in December 1864 to 671 vessels, manned by 51,500 men. Most of those vessels had been obtained from the merchant service, and were, of course, not fit to encounter hostile fleets at sea, but they were well adapted to the peculiar work required of them.

Russian merchant steamers converted into cruisers.

On the outbreak of the war with Turkey the Russians proceeded at once to organise a naval force in the Black Sea, composed of merchant steamers. Nineteen vessels were purchased for this service from the Odessa General Steam Navigation Company. The four largest ships were furnished with guns and were sent to sea as cruisers. Their names and dimensions were as follows:—

—		Tons	H.P.	Guns	Mortars
Rossia . . .	Screw steamer	4,200	280	10	2
Vesta . . .	„	1,800	130	4	5
Vladimir. . .	„	1,600	160	4	4
Grand-duc Constantin	„	1,480	160	4	4

The 'Vesta,' under Captain Baranoff, was reported to have been engaged with a Turkish ironclad, and escaped without serious injury.

When the complications in the relations between Russia and our own country became so serious that diplomatists began to despair of a peaceful solution, an appeal was made by the Czarewitch for private subscriptions for the purchase and equipment of a fleet of privateers, equally adapted for the purposes of commerce and war. The first vessel the Russians acquired was the Hamburg and American Company's steamer 'Cymbria,' of 3,025 tons and 500 horse-power, built at Greenock in 1867 by Messrs. Caird. The first American-built vessel purchased by Russia was the 'State of California,' built at Philadelphia, of 2,500 tons and 400 horse-power, and the first iron ship built under Lloyd's survey in the United States. The next was the 'Columbia,' now called the 'Asia,' and the 'Saratoga,' now the 'Africa.' In addition to these three vessels, a new ship for cruising purposes, of the 'Alabama' type, named the 'Zabijaka,' was ordered from Messrs. Cramp, of Philadelphia.[1]

H.M.S. 'Hecla.'

While the Russians were making their purchases in the United States, the merchant steamer 'British Empire,' now called the 'Hecla,' was purchased by our own Government, and converted into a torpedo-ship, fitted to carry fast torpedo-launches, and to

[1] See vol. i. pp. 536 7.

follow in the wake of a fleet as a dépôt, ready to despatch her flotilla of small craft for their protection when necessary. She is also fitted as a workshop for the repair of torpedoes.

In the fighting ships of the Royal Navy the engines and boilers are always kept down below the water-line, so as to be protected from horizontal gun fire. The reduction in the height of the engines of her Majesty's ships involves a greater space in the breadth of the ship. In the 'Hecla' the height of the engines admits of a limited breadth, and leaves ample room for bunkers. Advantage has been taken of this circumstance to give protection to the cylinders and boilers by means of permanent bunkers, filled with coal, with intervening thin iron plates. The 'Hecla' is fitted with ports for using torpedoes. As a means of defence she is provided with a strong wire net suspended from booms. The dimensions of the 'Hecla' are as follows: Length, 390 feet; breadth, 38 ft. 6 in.; depth, 28 feet; gross tonnage, 3,573 tons; displacement, 6,000 tons. She is divided into seven main watertight compartments, has two complete iron decks, a long deck-house amidships, and a light forecastle or 'turtle back.' She has four iron pole masts and a fore and aft rig with square sails. The speed is thirteen knots.

Admiralty Circular.

The action of the Admiralty has hitherto been limited to the issue of a circular inviting the shipowners of the United Kingdom to furnish drawings of their vessels.

Where certain bulkhead conditions have been complied with, the names of the ships have been entered in a list; but hitherto no practical advantage has been given to the shipowners. They have asked for some additional encouragement in the form of an annual subsidy. A proposal to this effect was urged in an able article in the *Nautical Magazine*, in 1876, by the late Mr. Lindsay. The same subject was more fully discussed by Mr. John Burns, in an article contributed to the *Nautical Magazine* of June 1878.

A subsidy recommended by Mr. S. H. S. Lindsay.

Mr. John Burns.

Sir Donald Currie.

In his lecture at the United Service Institution, Sir Donald Currie suggested a proposal for the consideration of the Government very similar to that of Mr. John Burns. 'Let the Government,' he said, 'select ten or twenty or thirty steamers (if they can find that number) capable of steaming over twelve knots an hour for twenty-five to fifty days without stopping. Engage these vessels upon some such terms as these :—A payment monthly, or by the year, for their retention; make it an obligation on the owners to retain in their employ men connected with the Royal Naval Reserve. Let the Government keep at certain specified places, such as Ascension, the Falkland Islands, Simon's Bay, Hong Kong, Sydney, Halifax,

Bermuda, Vancouver's Island, and other strategical points, a sufficient number of men of the Royal Marine Artillery and Infantry with guns, fittings, magazines, ammunition, torpedoes, etc., to be available when required; and prepare the necessary means for arming the vessels retained, which otherwise would be employed in their regular trades.' In a speech to the electors of Midlothian, the Prime Minister spoke with favour of the suggestions which had been made by Sir Donald Currie. Sir E. Reed has long been favourable to the payment of a subsidy to certain selected vessels of the commercial marine. The general employment of iron and steel in ship-construction, the increase in the power of light armaments, and the introduction of the sea torpedo, are all changes tending, as he has shown, to raise the value of commercial vessels as auxiliaries to the navy. In the discussion on Mr. Barnaby's paper on 'The Fighting Power of the Merchant Ship,' read at the Institution of Naval Architects in 1877, Mr. Reed proposed that shipowners about to build large and swift merchant steamers should be invited to submit their plans to the Admiralty, and that the cost of any alterations which they might be willing to make to adapt their vessels for the emergency of war service should be met by a grant from the Government.

Sir E. J. Reed.

There can be no question as to the absolute necessity in time of war, of supplementing the regular force by purchasing the best steamships in the mercantile marine. It is indeed a proposition which needs no demonstration, when we consider that the total tonnage of the British empire is 8,329,421 tons, and that the ratio of mercantile tonnage to naval is 28·00 for Great Britain, as compared with 5·75 for France and 5·58 for Russia.

Various opinions as to annual subsidy.

But, while all admit the dependence of the navy on the mercantile marine, there is a wide difference of view as to the expediency of paying an annual retainer to secure a reserve of fast cruisers. It is strongly recommended by some. It is disapproved by others. As an alternative a provisional agreement with the owners has been suggested under which they are to guarantee not to sell their ships to any foreign Power without first offering them to our own Government on the same terms. It is admitted that if a war were to break out a high price would be asked, but it is contended that we should have the certainty of securing the vessels when required, and that we should escape an annual charge to meet an uncertain contingency. As to the certainty of securing the vessels, some doubt has been entertained. There would be nothing to prevent a shipowner from selling his ship at any time prior to a declaration of war, and a war may be

secretly contemplated in a time of apparently profound peace. Our very fast steamships are limited in number, and could all be taken up by the belligerents, and incorporated during a war in the State navies of foreign and possible hostile Powers. The British ownership of a magnificent steamship is a slight national tie. It binds to no national service while it exists, and it may be broken without warning at the will of the owners. At the commencement of the Russian scare great temptations were offered to the owners of the White Star steamers, now running between San Francisco and Japan, and it is not too much to say that our whole commerce in the Pacific would have been transferred to the flag of the United States if that offer had been accepted.

It is further to be considered that, while the expenditure will certainly be very large whenever tonnage is taken up for war service, on the other hand, the contingency being uncertain, prudent shipowners will hesitate to incur serious expenses in preparing their vessels for conversion into armed cruisers. Alterations of ships for such a purpose must necessarily involve delay, and prove less satisfactory, while costing considerably more than similar adaptations for war service incorporated in the original design. In the case of vessels which it is proposed to subsidise as cruisers, the shipowners should be invited to submit the designs to the Admiralty before the actual construction has commenced.

The recent changes in naval architecture have brought the first-class merchant steamer and the unarmoured ship of war very near together in fighting power. It will probably be found that these swift and powerful ships, which alone it would be worth while to subsidise, could be adapted for service as cruisers at a small expense and without detracting from their utility for commerce. Where, for example, the multiplication of bulkheads would be inconvenient, frames could be introduced to receive bulkheads when required. In large steamers the boilers and machinery might be protected by armour. Shelf-pieces for carrying armour-plates could be introduced, and the armour could be kept in store ready to be fixed should the vessel be required for war service. The cost of such alterations might be borne by the Admiralty; but it would be comparatively moderate. The sum of 30,000*l.*, well laid out, would probably suffice for a large ship. By watching carefully the shipbuilding operations of the mercantile marine, and securing as auxiliaries for the navy any vessels of exceptional speed, a reserve fleet might be gradually created which would add incalculably to our strength, and cost a sum altogether insignificant in comparison with the expenditure required

for a fleet of unarmoured cruisers equally numerous and of the same high speed.

Vessels capable of steaming seventeen knots could not be built for the navy for less than 200,000*l*. Some protection might be given to the boilers and machinery of the largest merchant steamers at an expenditure not exceeding 30,000*l*. It is unnecessary to insist on the conspicuous advantages of such an expenditure on the mercantile marine, if brought to the practical test of a naval war. For a sum of 1,000,000*l*. sterling no less than thirty swift cruisers might be added to the navy. The protected merchant steamers would be individually no match for the regular war cruisers; but they would be fit for the service they were intended to perform. They would be able to sweep the ocean and to capture privateers.

Suggested subsidy.

The policy of giving annual subsidies to certain vessels specially adapted for service as mercantile auxiliaries has been often under consideration. It has been decided that the objections are too serious to justify the British Government in following in the line taken by the French Administration. In any case, the subsidy to mercantile auxiliaries should be limited to ships of not less than 4,000 tons gross register with a blue-water speed of sixteen knots. A subsidy granted under such conditions would operate as an inducement to shipowners to put more powerful machinery into their ships. This point may be illustrated by a few examples of ships quite recently launched.

Encouragement to build ships of high speed.

The Peninsular and Oriental Company have lately constructed three ships of 3,500 tons and 700 nominal horse-power. One of these, the 'Ravenna,' made the passage from the Clyde to the Thames at a speed of 14·6 knots. At a meeting of the Company the chairman announced that three additional ships had been ordered; one to be named the 'Brindisi,' of 3,600 tons, with 560 horse-power. The two others would be constructed with high postal speed equal to fifteen knots an hour, and would be 430 feet long by 44 broad, and 22 feet draught, thus having a displacement of 7,800 tons.

As it was determined on strictly commercial grounds to build two 15-knot ships, it is probable that the four other vessels, and the 'Trojan,' of 3,554 tons, lately built for the Union Company, which had a measured mile speed of 14·975 knots, would have been engined to steam at least sixteen knots, if the Admiralty had offered a premium to ships capable of attaining a specified rate of speed.

Rates paid for transports.

It has been urged that we ought not to burthen the navy estimates with a charge for subsidising auxiliary cruisers, which may probably never be required for active service; but if this subsidy could be so arranged as to include an engagement for the hire of

the subsidised steamer at reasonable rates for transport service, the plan might recommend itself even to the most rigid economists. In the late Abyssinian expedition the sum of 3,500,000*l.* was paid for the hire of transports, and the rates paid were so enormous that the British Indian Steam Navigation Company received for the hire of 10,114 tons of shipping for nine months and eighteen days, the sum of 257,460*l.*, or 25*l.* 9*s.* per ton; the Bombay and Bengal Steam Navigation Company having actually offered to sell their fleet to the Government at 27*l.* per ton.

The following cases are selected from the abstract of the charter-parties of the transports engaged to convey the Indian contingent from Bombay to Malta:—

—	Tonnage	Rate per month
		£
St. Osyth	3,541	6,816
Macedonia	2,272	3,976
Nankin	2,423	4,240
Bangalore	2,342	5,123
Trinacria	2,246	3,932

When the reinforcements were despatched to the Cape, although the shipping trade was in a state of considerable depression, the following rates were paid for the hire of transports:—

Steamship	Tonnage	Per month	Terms of hiring
England	4,897	20*s.* per ton	3 months certain
Egypt	4,617	20*s.* per ton	3 months certain
Spain	4,512	22*s.* 6*d.* per ton	3 months certain
France	3,571	20*s.* per ton	3 months certain
Manora	3,242	10,000*l.* down	To discharge at Cape
City of Venice . .	3,206	25*s.* per ton	3 months certain
Queen Margaret .	3,138	22*s.* per ton	3 months certain
City of Paris . .	3,081	25*s.* per ton	3 months certain
Russia	2,959	25*s.* per ton	3 months certain
China	2,638	25*s.* per ton	3 months certain
Olympus . . .	2,415	25*s.* per ton	3 months certain
Clyde	2,283	20*s.* per ton	3 months certain
Andean	2,147	20*s.* per ton	3 months certain
Palmyra	2,144	25*s.* per ton	3 months certain
Natal	—	1,500*l.* per month	2 months from 1st April
Loanda	1,476	20*s.* per ton	3 months certain
Florence	616	1,350*l.* per month	2 months. To discharge at Cape

In the recent negotiations with the Peninsular and Oriental Steam Navigation Company for the renewal of their contract no ar- Peninsular and Oriental contract.

rangements were entered into with reference to the transport service. The usual clause, empowering the Admiralty to purchase or charter any vessels employed in the mail service, is common to both the old and the new contracts. When the Indian contingent was brought from Bombay to Malta the Government received no assistance from the Peninsular and Oriental Company. In reply to a question asked in the House of Commons by Mr. Baxter, Lord John Manners said that only one of the ships of the Peninsular and Oriental Company was engaged at Bombay to bring up a part of the Indian contingent to Malta, and she was discharged as soon as possible in consequence of the high rate at which she had been chartered. In the recent instance of sending troops to the Cape the Peninsular and Oriental Company was invited to tender, but did not do so.

General arguments for subsidy.

The payment of an annual subsidy would constitute a small charge in comparison with the cost of any single vessel in the navy approaching in point of speed the magnificent steamers in the Atlantic trade. We have built the 'Nelson' and 'Northampton,' for the protection of commerce, at a cost for each ship considerably exceeding 300,000*l.* The cost of the 'Volage' and 'Rover,' the smallest of our nine fast unarmoured ships, was 127,050*l.* each. With the present estimate the mercantile marine affords the only means by which the number of cruisers equal or superior in speed to the French could be rapidly increased.

Unless encouragement be given in time of peace to the construction of suitable ships, we may look in vain to the mercantile marine in the hour of need for auxiliary cruisers. No other nation has such vital interests at stake in a naval war; or the same facilities for creating a powerful fleet on such easy terms to the taxpayers.

Such are the arguments which may be urged in support of the policy of giving subsidies to the owners of steamships, selected for their speed, coal-endurance, and seaworthiness, as specially adapted for conversion into auxiliary cruisers. It has not been thought necessary in the present republication of papers and speeches to suppress what was formerly advocated without the knowledge and without the responsibility of an official position at the Admiralty. With increased experience the compiler has become more fully sensible of the objections to the plan of subsidies. In giving the aid of the State to certain favoured shipowners, and refusing it to others, it is probable that enterprise will on the whole be checked rather than encouraged. We shall return to this aspect of the question at the close of the present chapter. For the moment it will be sufficient to say that the present Board have, in the judgment of the compiler, been well advised in

not committing themselves to engagements which are not generally nor strongly approved by the shipowners themselves, which must necessarily be complicated and embarrassing in their terms and conditions, and which, if carried out on an adequate scale, would impose a serious charge on the Navy Estimates.

The policy of giving subsidies to mercantile auxiliaries being dismissed from our view, it becomes important that the vessels in receipt of postal subsidies on the ocean routes should be convertible into cruisers. **Connected with mail service.**

In reply to a question asked in the House of Commons by Mr. Baxter, in the session of 1880, Mr. Fawcett said, the annual loss in the revenue of the United Kingdom on the contract of 1874 for carrying mails between this country and India, China, and Australia, was, in 1876, 216,000*l.*; in 1877–78, 239,000*l.*; and the estimated loss in 1878–79 was 246,000*l.* The contract speed of the Peninsular and Oriental Company, for carrying mails *via* Brindisi to India, China, Australia, was 11⅓ knots an hour. The average time taken by the Peninsular and Oriental Company's steamers between London and Melbourne *viâ* Brindisi, in the transmission of mails, was 39½ days, and that time, he believed, had been in only one instance exceeded. It was true that the average rate of passage in the vessels of the unsubsidised Orient Company was considerably faster than that of the subsidised line of the Peninsular and Oriental Company. The average rate of speed of the former was between 14 and 15 knots an hour, and from information sent to the Post Office he believed the length of the passage from Plymouth to Adelaide, the first port at which they stopped, was a few hours under 40 days. In one instance the passage was completed in 35 days. We are paying 360,000*l.* a year, with an additional contribution of 80,000*l.* from the colonies, for the conveyance of mails to the East, along routes daily traversed at equal speeds by unsubsidised steamers.

When the contract with the Peninsular and Oriental Company was renewed, it should have been made a condition that vessels employed in a service so liberally supported by the State should be capable of steaming 16 knots. It may not be necessary that the mails should be carried at greater speed than at present, but all the vessels employed should have been adapted for conversion into cruisers, and for that purpose they must be fast.

In the opening of the present paper a detailed comparison was given of the speeds of the English and French unarmoured ships of the latest types. The French have 27 cruisers built and building

of greatly superior speed to any English cruisers except the nine first and second class ships. The French mercantile tonnage is under 1,000,000 tons, while our own exceeds 8,000,000 tons. The population of France can be sustained on the resources of their own country. Half the bread, and vast quantities of the food of other descriptions, consumed in the United Kingdom, are imported from beyond the sea. To England, therefore, it is of vital moment to guard and patrol our ocean highways, and yet in actual preparations we are far behind the French navy in the number of our fast cruisers. The enemies of England will make her commerce the first object of attack, and that attack will be conducted, not by powerful fighting ships, but by vessels with light armaments, able to destroy a helpless merchantman, or to fight a lightly-armed cruiser. From a powerful man-of-war they would seek to escape by their speed.

Further arguments for subsidy. Our merchant service presents a vulnerable area to attack; the larger in proportion as our commerce exceeds that of any other country. But if it can be made self-defending, we shall have converted an element of weakness into an engine of power; we shall have strengthened our navy without increasing our expenditure.

Necessary limit to naval expenditure. Certain axioms may be laid down, which cannot be too constantly present to the minds of those who control or criticise the management of the navy:—

I. There must be a limit to expenditure. Even when the nation may be anxious to vote lavish sums for the navy, a wise statesman will restrain the impulses of patriotism, knowing that a prodigal outlay on our part will probably arouse the jealousy of foreign powers.

II. The expenditure on naval construction should be devoted mainly to ships intended for the line-of-battle. The type will vary with the progress and the modifications of naval warfare; but, whatever the type may be, it is to the production of the most powerful fighting vessels that the resources of the navy should be principally directed.

The funds at the disposal of the Administration are not unlimited. Expenditure in one direction implies economy in another. It should, therefore, be the aim of the Government to avoid building ships for the navy of a type which can readily be obtained, in case of need, from the mercantile marine. The unarmoured fleet must be kept up to furnish the necessary reliefs for foreign stations, and sufficient ships for the training of seamen. But our shipbuilding vote should be expended, as far as possible, on vessels both armoured and unarmoured, which are specially adapted for fighting, whether with the gun, the ram, or the torpedo.

It is not in substitution for frigates or corvettes, but as supplementary to the permanent force of the navy, that mercantile auxiliaries are recommended. It has been thought expedient to engage a certain number of the merchant seamen to serve in the navy, by giving them an annual retainer during peace; it is equally necessary to create a reserve of ships. The present estimates are utterly insufficient to create and maintain such a fleet of unarmoured vessels as would be required to protect our valuable and scattered commerce in the event of war. That commerce would be assailed, as we learned during the Russian scare, by merchant steamers converted into cruisers. Our own mercantile auxiliaries would protect us from the attacks of similar vessels in the service of the enemy. It has been freely and fully conceded that merchant steamers will be inferior to ships specially designed for war; but that admission must be made with some reservation. It is an inferiority in offensive, not in defensive strength. Fighting ships, as Mr. Barnaby says in his pamphlet on the 'Inflexible,' may be divided into two classes, protected and unprotected. In none of the unprotected ships is there any protection against shell-fire, except such as may be given to engines and boilers by coal. The ordinary merchant ship, if properly divided into compartments, may be quite comparable in defensive strength with the regularly-built war ship of the type of the 'Inconstant,' 'Raleigh,' 'Boadicea,' 'Volage,' and smaller ships.

If it were known that the resources of the mercantile marine had been rendered promptly available by timely and careful organisation for the purpose of defence, the influence of the country as a maritime power would be strengthened in no inconsiderable degree. It would be felt that in the hour of need the royal and the merchant services were one navy, incomparably the most numerous and the most powerful in the world.

If only to be used as transports, a certain number of ships of a speed which will defy the pursuit of hostile cruisers will constitute a most valuable resource. We shall be able to despatch large bodies of troops in these swift and powerful ships without escort and without apprehension that they may be intercepted on their voyage. It is further to be observed that the interruption of the traffic by the Suez Canal is one of the most probable events which would happen in a European war. By encouraging shipowners to build a few ships of the speed and coal-endurance of the 'Servia' and 'City of Rome,' we should be able to accomplish the circumnavigation of the Cape with such accelerated speed that the interruption of our shorter communications by the canal would be practically unfelt in India.

Objections may be urged of considerable weight to the appropriation of naval funds to the mercantile marine in time of peace; but, as the artist in *Rasselas* truly said, 'Nothing will ever be attempted if all possible objections must first be overcome.' No objections can be urged to the enforcement of the necessary conditions as to speed and bulkheads in the postal contracts. This alone would furnish the country with a powerful fleet of auxiliary cruisers.

Objections to subsidies to mercantile auxiliaries.

The arguments for a subsidy have been set out at length in the preceding pages, but the compiler fully recognises the objections to the plan. Where certain vessels and certain fortunate shipowners are supported by an annual payment from the State, an invidious distinction is created. The conditions, again, on which the subsidy should be given, are not easy to define. In the meanwhile, a great work is being accomplished by a simple agency, of which none can disapprove. Every steamship in construction, adapted by speed and coal-endurance to be an auxiliary cruiser, is so designed as to satisfy the bulkhead conditions. The influence exercised by the Admiralty list has been most beneficial to the mercantile marine. It has created a vast reserve of ships available for naval purposes; and this great result has been brought about by the Controller and the constructors, with the co-operation of the shipowners, without cost to the Exchequer.

CHAPTER V.—(*Continued*).

UNARMOURED SHIPS.

Section VI.

Mercantile Harbour and Coast Defenders.

In the preceding observations attention has been directed to the defence of the ocean highways. In the tug and ferry boats which are to be found in such large numbers in our great seaports, we possess the means of extemporising a powerful flotilla for coast defence. **Coast defence.**

Sir William King Hall has proposed that gunboats should be stationed round the coasts, especially round those of Scotland and Ireland, in pairs. A half-pay officer, an engineer, and one or two men would be sufficient nucleus for a seagoing crew. At the conclusion of the fishing season the vessels should be manned by crews drawn from the immediate vicinity, and proceed to sea for a month's training. **Sir William King Hall.**

In consultation with Mr. Laird, of Birkenhead, a scheme was prepared in 1859 for the local defence of the port of Liverpool. In a letter to the Secretary of the Admiralty, of July 7, 1859, Mr. Laird said, 'There are on the Mersey a great number of ferry and tug boats, which at a moderate outlay, say about 200*l.* to 250*l.* for each boat, may be strengthened sufficiently to carry heavy guns, from 32 to 68 pounders. **Mr. Laird.**

'I will consider, first, the boats carrying passengers between Birkenhead and Liverpool by Woodside ferry. These boats are about 125 feet long, 22 feet beam, and draw about six feet water. They occasionally carry on deck 600 to 800 passengers, or say about 40 to 50 tons dead weight; and with this weight on deck they are perfectly safe, and fit to contend with the rough weather we occasionally have on the Mersey. Six of these boats would be able to carry two 32-pounders or one 68-pounder each; and as a proof of this the "Pruth," a gunboat I built for the Russian Government,

155 feet long, 22 feet beam, carried four 32-pounders with ease, and has proved a most efficient vessel.

'There are also a considerable number of very efficient tug-boats on the river capable of carrying heavy guns, as well as the ferry-boats plying to the various ferries on the river, in addition to those I have named as working from Birkenhead to Liverpool. These boats can be fitted to carry one pivot 32-pounder gun.'

Sir William Mends. Their lordships were so far impressed by the proposal that they called upon Captain (now Admiral Sir) W. R. Mends, C.B., Director of Transports, to make further inquiries and to report generally on the scheme. The substance of Captain Mends' report was as follows :—

'First. That I think the proposal a good one, practical and practicable, inasmuch as boats of that description plying on this river are of considerable strength, superior capacity, carrying from 600 to 800 persons frequently, of light draught of water, and would bear with ease, in ample space for work, two 56-cwt. 32-pounder guns, or one 95-cwt. 68-pounder gun, and one 56-cwt. gun. Such vessels, fitted as suggested, would form an auxiliary force to that of Her Majesty in the protection of the river or adjacent coasts that cannot, in my opinion, be too highly estimated.

'Secondly. That the fact of their being so fitted and occasionally exercised might deter an enemy from making a hostile attempt upon the river, and would certainly inspire confidence in the community, which does not at present exist.'

This report also gave details of the cost of conversion and the annual expense of training the crews; and plans, by Mr. Laird, of vessels showing the proposed mode of fitting the guns, together with submissions from the owners of the boats as to the terms on which they were willing to enter into the scheme, were enclosed.

On the receipt of this report, Admiral Sir Baldwin Walker, then Surveyor of the Navy, sent down an officer of his department to arrange the terms on which one of the ferry-boats could be purchased

Mr. Luke. and fitted as a model according to the proposed plan. Mr. Luke, the gentleman sent on this duty, reported his opinion, that many of these vessels (*i.e.* the ferry and tug-boats) could be sufficiently strengthened to carry two guns, and be made available as an auxiliary force for defending the entrance to the river Mersey; that the boats should be divided into three classes, according to the weight of the two 32-pounder guns each boat was to carry; and that the cost of fitting one of them would be 290*l.*, which with 147*l.* as the hire of the boat during the process of fitting, would amount to 437*l.* No further action has since been taken, and Sir William Hall, in his

stirring pamphlet, entitled 'Wake, England, wake!' has shown how desirable it is that the subject should not be neglected.

Since the report of Sir William Mends was prepared, the torpedo has been introduced. We have seen, in the extracts which have been given from Admiral Scott, that it is a weapon which can be employed with the greatest advantage by our fishermen and coast population. A successful attack on our shores would be practically impossible with a proper organisation of our large flotilla of tugs and river steamers capable of acting as rams, torpedo, or gun-vessels.

Whether we look to the protection of our commerce on the high seas, or the defence of our harbours, the mercantile marine is an essential element of naval strength. Lord Bolingbroke has truly said: 'By trade and commerce we grow a rich and powerful people, and by their decay we grow poor and impotent. As trade and commerce enrich, so they fortify our country. The sea is our barrier, ships are our fortresses, and the mariners that trade and commerce alone can furnish are the garrisons to defend them. Like other amphibious animals, we must come occasionally on shore; but the water is more properly our element, and on it, like them, as we find our greatest security, so we exert our greatest force.'

CHAPTER V.—(*Continued*).

UNARMOURED SHIPS.

SECTION VII.

Discussion at United Service Institution.

As a supplement to the preceding section the discussion at the United Service Institution on a paper read by the Compiler on June 23, 1876, is here inserted.

Commander Dawson, N.R.

Commander W. DAWSON, R.N.: 'It is a very important question whether in a national emergency this country cannot have the benefit of the services of some 4,000 or 5,000 splendid steamships, and whether no means can be devised for converting these steamships into valuable auxiliary engines of war for the defence of the country. You, Mr. Chairman, may remember better than I do, how about a quarter of a century ago a Committee of Naval officers was appointed to consider the armament of merchant steamships. In those days we had not the mechanical means of mounting guns which Captain Scott has now provided us with, and it was decided that it would require a good deal of strengthening to the decks and beams of these ships in order to make them fit to mount and work even the 32-pounders of that day: but I take it there would be no difficulty in the present state of mechanical science in mounting, say 64-pounders, in most of the seagoing steamships of the merchant navy. It is true that it is a question of expense, but we are speaking of an occasion of a maritime struggle for national existence, and then expense must be thrown to the winds. It would not then be a question of 10,000,000*l.* or 11,000,000*l.* for the Naval Estimates, but of saving the country. It is, therefore, a question that ought to be taken into serious consideration now, in the piping time of peace, in order that it may not only be done economically but efficiently and rapidly, when the time of trial comes. It would be well if the Government could experiment a little on merchant vessels of different

classes, in order to give naval architects and naval artillerists an opportunity of discovering what is the best and cheapest way of strengthening these ships, and what armaments they could most conveniently carry. For my own part, I see no difficulty in the way of strengthening any seagoing merchant ships by internal girders and cradle-work, so that she shall carry any sized gun. But no very extreme weight of ordnance is required. What is required is this, that merchant vessels may be made capable of carrying an ordinary gun; that their bows may be fortified for ramming, and that provision may be made for the use of various kinds of offensive torpedoes, so that, when called upon, they may be able to fight vessels of somewhat the same class. So far I quite agree with those who are of opinion that auxiliary unarmoured vessels converted from the merchant navy need not carry guns capable of piercing thickly armoured ships. But there is a class of unarmoured vessels beyond these auxiliary merchant ships—unarmoured men-of-war for attacking forts, and for other purposes—and the armament of those vessels is a disputed point. I am one in favour of the mixed armament which Mr. Brassey has put forward, but he has not quite brought forward my argument, which is this:—An English ship-of-war cannot always be the strongest in fight; she cannot always be the fastest on the seas, and she may be driven into such a corner that she cannot run away, and must either strike her flag or fight a far superior force. Her guns ought to be capable of perforating that superior force, whatever thickness the sides of the enemy's ships may be. If her guns are not capable of perforating the enemy she is perfectly helpless, and I do not think it is fair to send men in command of unarmoured vessels, armed with weak hitting guns, out to China or the Pacific, where they may be compelled to encounter ironclads. Let the guns be so powerful that the English ships-of-war, of whatever size, can pierce the hostile side, and then English captains need not be frightened because they cannot run away from a Japanese, a Peruvian, or a Turkish ironclad. This is why I am strongly in favour of mixed armaments for the smaller class of ships-of-war. With reference to the auxiliary force of cruising ships, there is no reason why the country should not be able to avail itself of the services of the steamships of the mercantile marine in case of war, if they be provided with guns, torpedoes, and fortified bows; and as to expense, that must be thrown to the winds in a national emergency.'

Rear-Admiral De Horsey: 'I feel particularly the importance of devising an effective plan for manning and arming the merchant navy; but I should like to suggest its being done in a different way. Prepar- **Rear-Admiral De Horsey.**

ing passenger and other merchant ships for carrying guns now in time of peace would lead to a very large expenditure, and I think the shipowners would not be satisfied, even if they were well paid, for they would say it interfered with their speed and the accommodation for passengers and cargo. I cannot see why the Government should not bring in a bill to empower them in the event of war to take such vessels as they required at a valuation, as they now take land for public works and for public convenience, as in the case of railways. How much greater would the cause be when it was for the safety of the nation in time of war! I think that no reasonable shipowner could complain if a fair sum was given him for his ship when she was wanted. With regard to strengthening an ocean steamer to carry guns I speak with diffidence in the presence of Mr. Barnaby and other naval architects, but I can conceive no difficulty whatever. Their hulls are as well able to carry 100 tons in the shape of a gun as in the shape of cargo. The part that requires strengthening is the deck, and our naval architects are quite able to put any amount of strengthening. I feel confident that they would make no difficulty about that in time of danger.'

Admiral Selwyn.

Admiral SELWYN: 'I am particularly able to confirm all that Mr. Brassey has said with regard to the value of the great ocean lines running across the Atlantic, since I have been very often across lately, and have seen vessels doing even better work than those of which he has given you the returns. Their fuel-power is extraordinarily great, and so is their speed, and these are two points on which we ought to be able to imitate them more nearly in the Navy. They will be of the utmost value in case of war, when we shall be called upon probably to provide for the rapid carrying of troops to our colonial possessions. With regard to their carrying guns, I entirely agree with Admiral De Horsey and others that there would be no real difficulty if you give them the right carriages. The question of weights could be easily disposed of. The weight on deck is nothing in a ship of that size. Captain Pim has forgotten that length gives stability as well as beam. As to the question of subsidy in peace, I think it would be rather a wasteful expenditure, because our most durable steam-lines do not always remain in the same hands, and in some cases the change is very frequent, and we cannot give an owner a subsidy when the ship would pass out of his hands. I would rather give the full value for the ship, as was done in the case of the "Himalaya," in the time of the Crimean war, with good effect. With regard to the torpedo, I quite agree with Mr. Brassey that it is a most admirable weapon, and even

that where no guns can be carried it would be most formidable in the hands of a fast cruiser. Those who dared to follow her, would very often find a torpedo in their path. The question on which I venture slightly to differ from Mr. Brassey is this: the Navy of England has, as its chief purpose, the protection of the commerce. Commerce must be carried on, if we would have the sinews of war equally during war and peace; and we cannot afford to take away the very best ships from that commerce at the moment when we are most pressed for our food and for other things which are essential to the well-being of the nation; and we must recollect that every vessel taken under those circumstances from the mercantile marine takes a certain portion from the sinews of war. If we are driven into a corner and overweighted, then it is quite clear that, as with volunteers so with the mercantile marine, every nerve must be strained to defend the Empire. For that purpose organisation and registration ought to take place now. Every enquiry ought to be made during peace, that we may be prepared to take them when the necessity arises. We ought to think that it is wiser to spend treble on the Navy for really efficient vessels during peace, than to divert to the mercantile auxiliaries sums of money which would provide the sinews of war when the necessity arises.'

Mr. BARNABY: 'I came here to listen to what might be said by Mr. Brassey, and by the gentlemen assembled here, and not for the purpose of saying anything myself. I feel as Mr. Scott Russell does, that I would like to hear all the Naval officers speak, and I think I may ask to be excused from saying more than one or two words. It is right perhaps that I should say this much, that the difficulty which is felt with regard to the use of merchant ships for fighting purposes is not with reference to the strength of their structure, nor their stability, but with reference to their division into compartments. It will be remembered by everybody here, that as iron came to be used very largely in the merchant navy, it was believed that the time was come for giving up that mode of strengthening the navy in time of war, and the Report of the Committee in 1852 was to the effect that those vessels being unfit for war purposes, the subsidies which had been granted ought to be put an end to. Fresh light and the introduction of better material and better modes of construction, and other weapons than guns, have brought us round to the conviction that iron ships built for mercantile purposes may be armed and used certainly for their own defence in time of war, and possibly also as auxiliary to the Royal Navy; but I would point out again that the one difficulty that has to be overcome is, that the merchant ships Mr. Barnaby.

which are being built, and some of the grandest among them as to speed, coal-carrying power, and seagoing qualities, are deficient in what we consider ought to be a necessary provision for security against foundering in the event of any one of their compartments being damaged. What the arrangement with the owner should be is a question which is undergoing the consideration of the Admiralty, and you will excuse my saying anything further upon it.'

Mr. Scott Russell.

Mr. SCOTT RUSSELL, F.R.S.: 'Sir, if no more sailors will do us poor shipbuilders the honour of confiding to us their views on this subject, I will give you mine. I will use Mr. Brassey's words: "The superiority of our resources will not give us any proportionate advantage without complete and careful organisation." And what does organisation mean? It means what Lord Palmerston said, arranging for war long beforehand, during peace. Now, if you ask me whether suddenly and abruptly, and all at once, on a demand from the Admiralty, we would undertake to select for them vessels which would be good, sound, safe vessels, capable of being armed even with the most ordinary guns, and engaging with anything like fair security in war, I say we could not take that responsibility; we won't take that responsibility. Therefore I hope Mr. Brassey's paper will be received with the greatest possible weight attached to its last sentence, and that you will believe that the great mass of those ships which he has quoted are not at all to be relied on for war purposes. Now, I wish I could say that we English are in a condition to defy everybody; that we are stronger than all the rest of the world put together. Gentlemen, I should be a traitor to you if I said so, because I should lead you to trust to a broken reed. Those vessels which Mr. Brassey has so eulogised are vessels which, with a very slight blow from a rock, or a rocket, or any of those ingenious weapons which we see exhibited in this place, would certainly go to the bottom. Therefore, I entreat you to place no faith in them. I do entreat you, on the other hand, to place faith in vessels which Mr. Barnaby and the Admiralty may be building, unarmoured, but with great precautions, trying to make them as safe as possible, and with power to carry certain guns. But as we are all friends and countrymen here, will you allow me to tell you of a terrible blunder you have made? I think about forty years ago I was asked to take the responsibility of building four Royal Mail steamships to carry mails for you at the greatest possible rate then known. I built you your ships; they were the fastest of the whole of that fleet; they were quite satisfactory; but what did you do at that time? You did this; you made me responsible to you that those ships should be

capable of carrying guns, and before you would give the ships their subsidy for carrying the mails, you made them satisfy your Admiralty that they were seaworthy and able to protect their mails against invaders. Why have you dropped that? Can anybody tell me that you still do that? I asked the highest possible authority the other day what he could tell me about that, and he said he had never heard there was any such thing. You are now paying all the money you give for the mail service to magnificent fleets of ships without ever once asking whether those original arrangements have been adhered to, and whether the vessels are fit to be trusted in time of war. Now, I ask you Members of Parliament, what representatives are you of the public interest if you have allowed that sort of thing to go on! And now you come and read your papers! Why, if you had looked into the accounts of which you boast so much, if you had looked into the votes a little bit, you would have found that all that money that was paid to those companies on those conditions has not been earned. Now, I think you will agree with me that there are funds at the disposal of the nation for this honest national purpose, and following up what Mr. Barnaby has said, I will do what I have always promised I would when you sailors put me a difficult question, —I will give you a straightforward, open answer. You tell me that you want merchant ships to be ready for your purposes in time of war. You have only to let that generally be known; you have only to tell all the shipowners that you will give a preference to ships which have those qualities which you require; you have only to say that all your mail contracts shall include that condition which I have referred to; you have only to organise and arrange beforehand, and you will find one day that you can use all your Merchant Navy for war purposes, for it is not difficult to make them so. You have only to have a wise proportion of beam and depth; you have only to get a wise position for that beautiful element in our modern ships, which so many of you forget, the ballast! We have got ballast now without paying for it; we have got the most magnificent arrangement of ballast in our engines and boilers. If you put them in a foolish place, you make an unseaworthy ship; but if you put them in the right place, I become responsible to you that you can carry a large deck armament of those powerful 8-inch guns which we have been talking of. But if you do not do all this beforehand; if the Admiralty do not see that they are of the right proportions; and if the Post Office do not see that these things are carried out before they pay the quarterly dividends for carrying the mails, then they will not get them. Another thing you can perfectly well do to benefit the public and

the seafaring population: you can make it a sin by Act of Parliament to send a large merchant steamship to sea which was not practically unsinkable. You say that is nonsense. I say it is not nonsense, because the "Great Eastern" steamship, by the skill of a clever captain, who found out a rock in quite an out-of-the-way place, had a hole torn in the hull 83 feet long and nine feet ten inches wide in the centre, and with this hole in her bottom she went to the end of her journey. They tried to cobble it, and could not; and with this hole she came back from her journey. She carried all her passengers and cargo safe and dry to one end of the journey, and brought an entirely new set of passengers and cargo safe and dry to the other end. That she did, too, without being surveyed by the Admiralty, and without being chartered as a mail-ship. Now, I ask you, am I wrong in saying that if you will put the problem to us shipbuilders, we know how to accomplish it? I think I know, and I think Mr. Barnaby does, how to make a respectable seagoing steamship unsinkable by all the ordinary means; and I think he knows how to put on board such a ship a very large armament of guns, which may not be capable of encountering and sinking a fully armoured ship, but which will be capable of sinking a great many cruisers and privateers, and doing harm to a great many troublesome customers. Will you allow me to say one word as to how I should set about it in our private ships. I should like to have my unsinkable ships; I should like to have the ballast in the right place, which would be pretty low under the water; I should like to have my guns in the right place, and of a big diameter. I do not want to have them very heavy, because I do not want to be far away from the enemy; I want to come close to him. Give me big shell, big shot, and big bore; then with my fleet of twenty merchant ships I would surround this grand fellow with his 81-ton guns. I would pepper him, and if he sent one of his 81-ton shots through me here and there, I should not mind; if half-a-dozen of us sank it would not matter; if we sank him we should win the victory. Therefore, I entreat you not to arm those sinkable, incapable ships which Mr. Brassey has spoken of, with any hope of doing good, but return to your old ways as quickly as possible, and say that any person who desires the Government money must, in some way or other, put his ships into a condition to be fit to serve for purposes of defence in time of war against all vessels of his own class, whether they are called privateers or anything else.'

Mr. Butler-Johnstone, M.P.

Mr. BUTLER-JOHNSTONE, M.P.: 'I, too, in common with Mr. Scott Russell, was extremely anxious to hear all the naval men speak on this occasion, and I was equally anxious to hear the naval

architects, because it is essentially a question for naval architects as well as for naval men. But there is also another aspect of the question which is no less important. In old times there were two descriptions of ships which we sent out in case of war. There were the ships which had to fight the enemy's vessels,—and do what you like with the Cunard and White Star, and other lines, you will never make them equal in fighting strength to a vessel built expressly for that purpose, any more than you can make a carrier pigeon equal in strength to a hawk; but there was another class of vessels sent out, what we used to call specifically "cruisers," to prey upon the enemy's commerce, and to destroy his resources, and so put an end to the war. These fast-sailing clipper steamers are the very things which could, at a very small expense, be admirably adapted for that purpose. But if, as Mr. Scott Russell said, we made a mistake forty years ago relative to the contracts for mail steamers, what a gigantic, what a disastrous mistake we made twenty years ago, when we signed the Declaration of Paris; because even if you send out the cruisers, and cover the ocean with your fast sailing ships, carrying guns, there will be no commerce to prey upon. Do you suppose any enemy will be foolish enough to come out of his forts and fight your vessels when he can remain in, as the Russians did, and defy you? Nelson's great victories, Howe's great victories, how were they achieved? By putting an absolute embargo upon the enemy's commerce. The enemy came out to protect his commerce, and then you sank his fleet. But now, under the Declaration of Paris, the enemy's commerce will sail under a neutral flag, and there will be nothing for your cruisers to prey upon. You may spare yourselves taking any trouble about these armed vessels, for there will be nothing for them to do. You have plenty of ships of war to defy the enemy, but they will never come out to you; and as long as the Declaration of Paris is unrepealed, there will be no enemy's commerce to prey upon; and all these questions of turning our merchant steamers into ships of war are useless. There will be nothing for them to fight. In my capacity as Member of Parliament, I thought it my duty to put this aspect of the question before you.'

Rear-Admiral SCOTT: 'Mr. Scott Russell has given us a view of the future, but what we want is a correct knowledge of the present requirements. Of course you may find fault with the strength of merchant ships, but the point is to utilise them for what they are fit, and doubtless this very foundation force *can* be largely utilised. As Mr. Brassey has just left this theatre, I can freely refer to the great good he has done, in stirring up the authorities to inquire Rear-Admiral Scott.

whether our merchant steamers can or cannot carry guns. This question, and also the question as to the best use which can be made of the merchant navy during war, ought long ago to have been settled. At the commencement of the Crimean war, just before the sailing of Admiral Napier for the Baltic, when I had just returned from a special mission with the masters and pilots intended for his fleet, I put before the First Lord the suggestion of Mr. J. Bodie and the other masters, viz., the effect it would have if all the powerful steam-tugs were to be immediately taken up, armed, and sent off at once to Cronstadt to threaten St. Petersburg. Look at the moral force we should have exerted by their early presence. The First Lord, however, sent for me the following day, and said he had been considering the matter and would build some vessels, as was accordingly done, but they were built too late to take part in the war.'

CHAPTER V.—*(Continued.)*

UNARMOURED SHIPS.

SECTION VIII.

Letter addressed by the Compiler to the 'Times'—Published June 7, 1879.

A NAVAL RESERVE OF SHIPS.

Times, June 7, 1879.

Argument for creating a reserve of ships.

SIR,—Having lately been permitted to offer some suggestions in your columns on another subject of naval policy, it is with hesitation that I ask you to give me the privilege of addressing the public on the organisation of a reserve of cruisers in our mercantile marine. I have called attention to this question in a recent speech, delivered on the banks of the Mersey, at the head-quarters of the great shipping interest, and I desire to take advantage of a momentary lull in Parliamentary business for the purpose of creating a more general interest in the same important topic.

The whole mercantile marine of Great Britain should be regarded as part of our Navy. Every ship which is convertible into a vessel of war, and every British seaman, should be looked upon as part and parcel of our Naval Reserve. We have already created a reserve of men; it is necessary to complete the work by forming a reserve of ships. It should be one of the leading principles of our shipbuilding policy to limit the shipbuilding for the Navy, as far as possible, to types which do not exist in the mercantile marine. We must build a sufficient number of cruisers to furnish the necessary reliefs for our squadrons on foreign stations; but the fleet of cruisers which we maintain in peace could be expanded into a fighting fleet from our reserve of ships in the merchant service.

An attempt has already been made to create such a reserve. The Government has signified its willingness to enter all vessels fulfilling certain structural conditions in an official list. This is a step in the right direction. But no pecuniary consideration is offered to shipowners

who respond to this appeal; and unless some substantial encouragement is given, it is not reasonable to suppose that any considerable number of vessels will be built with such modifications as would be required to make them easily convertible into fighting ships.

Suggestions on points of detail.

Mr. Burns has pointed out the inadequacy of the present proposal. The necessary adaptations of structure should be introduced in the original design. Alterations are always costly, and often unsatisfactory. Shipowners should be invited to communicate with the Admiralty when they contemplate building new vessels of a certain tonnage and speed. The designs should be examined, and if they were found to be easily adaptable to war purposes owners would probably consent to arrange bulkheads, watertight compartments, and bunkers in accordance with the requirements, and, of course, at the expense, of the Government. The ships, having been fitted for the emergency of war service would be entered in the list of cruisers in reserve, and would be held at the disposal of the Admiralty, in consideration of a fair annual payment. Should a vessel be required for active service as a cruiser, the additional sum to be paid for the purchase or charter should be previously agreed upon. It may be objected that the modifications which the Admiralty would probably require would interfere with the accommodation for passengers or the stowage of cargo. I do not think the difficulty would be serious. Bunkers could be so placed as to afford complete protection to the boilers against all but the heaviest projectiles, without in the slightest degree interfering with the facilities for stoking. The multiplication of bulkheads might cause considerable inconvenience in a merchant steamer, but frames could be constructed at certain intervals apart to receive additional bulkheads which could be easily fitted if the ship were required for war service. In certain cases a shelf-piece might be fitted to receive a moderate thickness of armour-plating, which might be kept in store in readiness to be fixed.

Scheme requires public support.

I am well aware of the difficulty of securing attention to new suggestions. Naval officers are unwilling to see any portion of the money voted for the Navy expended on ships which may never carry the pendant. Their aim is to make the Royal Navy sufficient by itself to meet all the naval requirements of the country. It is a natural but an impracticable ambition. Public attention is with difficulty attracted to any subject not directly connected with the passing events of the day. Without the recurrence of disastrous shipwrecks, Mr. Plimsoll would have failed to catch the ear of the public; and until our commerce is cut up by some future 'Alabama,' it is possible that no effectual effort will be made to provide such additions to the cruising

strength of the Navy, as would certainly be demanded on the outbreak of a war, and in the absence of which our shipowners would probably be compelled to transfer their vessels wholesale to the flag of the United States.

'Trenton,' U.S.N.

I cannot close this letter without a passing allusion to certain foreign ships of war I have lately had an opportunity of visiting. As an example of an almost perfect cruiser, I may quote the 'Trenton,' of the United States Navy, with which I have been in company at Villafranca. The 'Trenton' is a spar-decked frigate of 3,800 tons, armed with 11 powerful guns, capable of steaming 14 knots, maintaining a high average speed with reduced boiler-power, and carrying sufficient coal to make a passage across the Atlantic under steam. This vessel is fully rigged, and quite successful under canvas, and is described by her officers as possessing admirable seagoing qualities. When compared with our own largest unarmoured frigates, such as the 'Inconstant,' the 'Raleigh,' or the 'Shah,' the 'Trenton' seems to combine every point of naval efficiency which they possess, whether for the protection or destruction of commerce, while the tonnage of the American ship is less than half the tonnage of our own vessels. As a cruiser of the first class in war and a training ship in peace, I commend the 'Trenton' to the attentive study of the Admiralty. As the ship will shortly visit the Thames, the officers of the Controller's Department will doubtless avail themselves of the opportunity of inspecting her.

'Duquesne.'

Among the many ships now assembled at Toulon, the 'Tourville' is one of the most interesting. In this and the sister ship, the 'Duquesne,' the French contractors have sought to rival, and even to surpass, the English ships of the same type. The displacement is 5,440 tons, and the nominal horse-power 1,800. A speed is claimed exceeding that attained in our own ships prior to the trial of the 'Iris'; and certainly in beauty and symmetry the French designs cannot be excelled. As a man-of-war, however, the 'Tourville,' in common with the ships of the same type constructed for the British Navy, possesses only one conspicuous quality—namely, that of speed; and I remain unconvinced, even by the common action of the French and English constructors, that the policy is sound of building ships so costly with so little fighting power. Ocean steamers could always be obtained for the exigency of war with scarcely inferior speed and greatly superior coal-endurance. The advantages of the 'Tourville,' the 'Shah,' and even the 'Iris' over the ocean steamers, which navigate the Atlantic with such remarkable success in all weathers, lie mainly in the arrangement of their bunkers and the multiplication of bulkheads. These

are modifications that could easily be introduced in a large number of ships in the mercantile marine. A valuable addition might thus be made to the strength of the Navy in reserve, while the annual charge on the estimates would be an insignificant item in comparison with the vast outlay on a single unarmoured frigate of the class represented by the 'Inconstant' and the 'Raleigh.'

Gibraltar, May 28.

CHAPTER VI.

HARBOUR DEFENCE AND COAST SERVICE VESSELS.

In the present chapter it is proposed to consider the *matériel* necessary for naval operations in the vicinity of the coast. The subject will be treated, as all naval questions have been treated in these pages, by bringing together extracts from the writings of the highest professional authorities. All that the Compiler claims to have done in the preparation of this volume is that he has spared no pains in the way of research. In the present case everything that has been published on the subject has been carefully examined, and the passages introduced into the text have been selected without bias in favour of any preconceived views of the policy to be pursued by the Naval Administration.

It will be the primary duty of the British navy to occupy and command the high seas; and we shall doubtless succeed in maintaining our position of pre-eminence on the ocean; but when the enemy has retired under the shelter of a fortified harbour, other operations of great difficulty must be undertaken for which a coast service flotilla would be required.

These points were ably discussed in the *Edinburgh Review*, in April 1878. The following passages are extracted from the article to which we refer: 'If we should be engaged in a naval war, offensive attempts against our coasts on a great scale are not likely to be attempted. A squadron of such ships, as we could without much difficulty equip, closing the mouth of the Mediterranean or the outlets from the Ægean, another the Baltic, and a third riding in the English Channel, would, under almost every imaginable combination of circumstances, place us in a position to defy any extensive threatening of our shores. Isolated attempts against them may possibly be made; and to provide against these will be the duty of the force detailed for coast defence. As far as we have been able to judge from the experience of modern wars—wars made, that is,

Edinburgh Review. April 1878.

within the second half of the present century—the weaker of two maritime combatants withdraws his heavier vessels within the shelter of his fortresses. Each of the opposing sides may, as in the Adriatic in 1866, at first and before the shock of battle has supplied a test, be disinclined to admit its inferiority to the enemy. An accidental encounter, or one undertaken to allay the jealousies and suspicions of allies, may thus be brought on; but on the whole we may repose confidence in the view that in a war with England the enemy's line-of-battle ships would be found covered by his fortress' guns.

'This imposes a new duty upon our fleet, if we are to capture or destroy that of our enemy, as the aim should be, and not merely neutralise it till the conclusion of the struggle. Such an operation as the reduction of a considerable maritime fortress is one which the recent progress of the art of war has intensely complicated. New weapons have been placed by science in the hands of the defence, against which the assailants have had but little chance of experimenting in actual conflict, and indeed few opportunities of devising counteracting agencies. The method of attacking powerful fortifications with ships has scarcely been approached, even in theory, since the great changes in the conditions of naval warfare. If tactical questions in general have not been sufficiently attended to, this has been almost entirely neglected; and if we have to undertake such an operation it will be the crucial test of modern naval power.'

The opinion expressed by the Edinburgh Reviewer, that we ought to be at all times free from apprehension for the security of our own coast, will be the firm resolve of the English people. We shall neglect an obvious duty if we neglect to make provision for the contingency, improbable as we may venture to regard it, of a temporary naval reverse.

Sir E. J. Reed, Birmingham, 1871.

The necessity of the precautions here suggested was strongly urged by Sir Edward J. Reed, K.C.B., in a paper on our naval coast defences which he read before the Midland Institute at Birmingham, on March 27, 1871. The following passages are taken from the paper in question:—

'But, strong as we are at sea, our seagoing squadrons do but compose our first line of defence; and in these days of scientific progress, and of novel powers of warfare, we dare not trust to this alone. A great disaster at sea must be provided against, and the coasts be made secure in case of our navy suffering reverses. I know of no reason to call in question either our ships, our officers, or our men. I can answer for the anxious efforts that have been made, not by the late Controller and myself only, but by skilful and scientific

staffs, both at Whitehall and in the dockyards, in order to give our ships all practical advantages.

'It would be criminal to place all our reliance upon our seagoing navy alone, and to leave any longer our great commercial emporiums without local defence. Now that is, in point of fact, their present condition. They are entirely undefended; and, not only is that the case, but there really are no vessels at the great naval ports adapted for their defence. I ought not, in strictness, to say "no vessels," because some half-dozen small sheet-iron gunboats do already exist, and I understand that three or four light draught ironclads are now in course of construction. I begin by saying that the problem before us, formidable as it undoubtedly appears, is in reality a very simple and soluble one. That it appears formidable enough, I admit, for it presents itself to us in the form of a demand for nothing less than a powerful flotilla of defensive war-vessels at each of some ten or twelve points of the coast. Nothing short of this will put London, Newcastle, Liverpool, Glasgow, Belfast, and other great cities and towns, out of danger of attack in the event of the protection of our seagoing squadrons being lost to them for a time. Each of the great rivers and great seaboard towns of the coast must be furnished with the means of sending out against an enemy an ample flotilla of vessels for giving a good account of him.

. . . .

'Let us turn first to the Thames, and ask ourselves whether we do not find there in abundance the conditions I have mentioned—great shipbuilding power and resources, and a population eminently well adapted for manning and working steam monitors and gunboats. The same is true, in greater or less degree, of the Humber, the Tees, the Tyne, the Firth of Forth, Aberdeen, the Clyde, Morecombe Bay, the Mersey, Milford, the Bristol Channel, Belfast, and some other places.

. . . . . .

'What no amount of money could possibly accomplish in the hour of necessity, can be perfectly well accomplished, on a very small expenditure indeed, during peace, if forethought, arrangement, and organisation be brought to bear upon its development.

'First, we must supply each port at which great maritime towns have to be defended with a very few small, inexpensive, light-draught armed vessels, made perfect for their purpose in every way, one of them (in the ports on the east coast at least) to be made of sufficient size and seaworthiness to enable her to cross the North Sea or the Channel with safety. These vessels are to fulfil a double purpose:

first they are to serve as patterns for all the remaining vessels of the war flotilla to be afterwards built, and as the nucleus in each port of the squadron of defence; and, secondly, they are to serve the purpose of training vessels, through which all the volunteer naval forces of the port should be passed, and in which they can keep themselves skilled and practised in the duties which in war would be required of them.'

Local coast defence forces.

The organisation of a torpedo corps, and a local force capable of manning gunboats for the defence of our seaports, should be among the first defensive measures to be studied during the leisure of peace. It will be a source of great satisfaction to the country to know that these most important subjects are now under careful consideration by a committee which has been appointed by the Admiralty and the War Office to examine the approaches to our most important mercantile ports, and to suggest the best means of defending them. The committee will take into consideration not only the *matériel* which will be required, but will also consider the most effective force that can be organised on the spot for the purpose of manning coast-defence vessels.

Committee on defence of commercial harbours.

Major Parnell, R.E.

The necessity for the combination of a naval force with land fortifications in the defence of our coasts and harbours was distinctly recognised by Major Arthur Parnell, of the Royal Engineers, in his exhaustive paper on the subject, read before the Royal Engineer Institute. He referred particularly to the new torpedo-vessels as giving a great advantage to the defenders of sea fortresses. 'There is something,' he said, 'very practical in a swift Thornycroft launch. These, and other torpedo-vessels, are peculiarly suited to nations of a maritime temperament. . . . A naval fortress should certainly have a number of these torpedo-vessels, among its defences, with (if possible) naval officers to command them; for, in spite of the coasting nature of their action, they necessitate a maximum of seamanship, discipline, and daring. A boom, a battery of two 64-pdrs., and a torpedo-launch, would form an efficient and economical defence for a small commercial harbour, and the mere knowledge of the existence of such a defence would be the means of protecting the fort from insult by isolated cruisers.'

Colonel Von Scheliha.

Having given the recommendations of an eminent naval constructor, and an officer of engineers who has given especial attention to these subjects in our own country, with reference to harbour defence, let us turn to foreign authorities. Many valuable lessons may be learned from the experiences of the Civil War in America, in which the naval operations consisted entirely in the attack and

defence of harbours, and forcing the passage of the rivers of the Southern States. The views of the officers engaged on the side of the Confederate States were thus set forth in a *Treatise on Coast Defence*, by Colonel Von Scheliha, an officer of engineers in the Confederate service:—

'A perfect system of coast defence must necessarily combine two elements: a local defence, based on the efficiency of batteries afloat and ashore, on obstructions and torpedoes; and, if the seeming contradiction may be allowed, secondly, an offensive defence, or the series of active operations which must be left to the conjoined efforts of the army and navy.

'The success of local defence supposes—fortifications that will withstand the fire of modern artillery; batteries able to affect the armour of ironclads, such as will hereafter be used in attacks on fortified points; and obstructions sufficiently strong to prevent the enemy's steamers from passing out of reach of these batteries without leaving them time for continuing their fire at close ranges. The success of an offensive defence, next to the strength and efficiency of the army and navy, will depend on the facilities that exist for the concentration of a sufficient force with which to hinder the enemy from establishing a lodgment at any given point on the coast, or should he have succeeded in effecting a landing, to oppose any further invasion.

'A navy so powerful as to be able to keep the enemy blockaded in his ports and prevent him from leaving his own shore, would naturally enough be the most efficient means of defence any country could create for her coast. But as such a project in most cases would present another financial impossibility, more feasible plans, better adapted to the means of each individual Government, must be devised. Among them the building of strong ironclad floating steam-batteries, and the construction of railroads, radiating, with their branches and telegraph lines, to different points on the seashore, recommend themselves as cheaper methods even than the erection of extended and costly permanent fortifications at points that, in themselves of no vital importance, do not contain navy-yards, arsenals, dêpots, &c., and which could be protected by forces stationed at suitable distances near the junction of railroad lines, and held in readiness for any case of emergency. Flying columns, detached from these forces in the direction of the coast, and seconded by the vigilance of the inhabitants of the districts threatened with an invasion, would observe the enemy and occupy him after a landing till assistance could arrive from the main force. A vigilantly per-

formed outpost service whereby fishermen, pilots, and other inhabitants, intimately acquainted with the hydrography of all approaches to existing landing places, and the topography of the surrounding country, will be able to render most valuable assistance, must lead to better results than the plan of studding the coast with fortifications that all require garrisons, and thus necessitate a scattering of forces.'

Admiral Porter, U.S.N.

Turning to the Federal side, we find that a combination of floating and fixed defences was considered indispensable to make a secure defence against the attack of a powerful fleet. In the following passage in his report to the secretary of the United States Navy in 1874, Admiral Porter presented the result of the experiences gained in important commands in the Civil War:—

Admiral Porter. 1874.

'Owing to the introduction of the torpedo as a means of warfare, it is not likely that any nation will attempt to invade the coast and harbour of an enemy as they once did, when protected by these devices, in addition to fort, monitors, and rams; nor can the ports of a belligerent be thoroughly blockaded if proper rams and torpedo vessels are built in sufficient numbers to operate outside. It is impossible to protect a harbour by forts and sunken torpedo-mines alone, for our experience during the Rebellion satisfied us that torpedoes, unless protected by powerful vessels and forts combined, would be almost useless.'

Admiral Hobart.

Admiral Hobart, who knows the coasts of America well, has recently contributed to the pages of the *North American Review* a paper on the subject of harbour defence. He concurs with Admiral Porter as to the necessity of combining monitors and torpedo-vessels with the stationary defences by means of forts. He considers that the United States require 'small, swift, heavily armed ironclads, to dart out at all hours and seasons, and harass an enemy's blockading squadron; to these should be added the new fearful and demoralising weapon—the torpedo.'

***Marine Verordnungs Blatt,* 1874.**

We now turn from English and American to Continental authorities. An article on harbour defence was published in November 1874, in the *Marine Verordnungs Blatt.* The writer deals with the types best adapted for coast defence. 'For warfare of this description,' he says, 'a special type will be required, the principal features of which should be:—

'1. A draught of water adapted to the special localities to be protected.

'2. Superior evolutionary qualities.

'3. Thick armour.

'4. A ram; the light draught of water, which necessitates a reduction in the other dimensions, rendering it impossible to mount sufficiently powerful artillery adequately protected in turrets.

'5. As, nevertheless, it is undesirable that such coast-defence vessels should be without the means of resisting the attack of an enemy, they should be provided with two guns of moderate calibre.'

On December 1, 1875, on the occasion of the first discussion in the German Parliament on the Navy Estimates, General von Stosch, replying to the deputy, Saint Paul Illaire, made the following remarks:— **General von Stosch.**

'In my opinion, the monitor is a very antiquated form of vessel. It is too exclusively a vessel of defence, and above all of local defence, to render it desirable that the large expense of adding one such ship to our little navy should be incurred. The substitution of three gunboats has become necessary since our progress in the art of torpedo warfare has placed us in a position to defend our ports by this means alone, the more so because in this manner the more or less local defence by torpedoes would be supplemented by a more vigorous defence by the gunboats. Moreover, as these gunboats will be armed with the most powerful artillery hitherto constructed, I believe that, in conjunction with the torpedoes, they would afford a far more powerful aid than would a single monitor.'

In Sweden great attention has been given to the subject of coast defence. It formed a prominent feature in the plan for the reorganisation of the naval forces of that country, which was laid before the Diet in 1876 in an official report by the Minister of Marine. He enumerates under four heads the main objects for which the fleet should be employed:— **Minister of Marine, Sweden.**

First, to keep the enemy at a distance from the most important landing places.

Secondly, to impede, if not to render impossible, a disembarkation of troops.

Thirdly, if a disembarkation be effected, to intercept as much as possible the communications of the enemy with his own country.

Fourthly, to check the advance of the hostile army by the operations of the fleet in the inland waters and in the archipelago of islands with which the mainland of Sweden is girdled.

The report contains a full discussion of the types of ship best adapted to carry out the policy of naval defence sketched out by the minister. The defence of the Archipelago requires, it is said, both a powerful artillery and a complete system of torpedo defences. Speed and seagoing qualities are of secondary importance for the

matériel constructed to navigate inside the islands and in the inland waters of Sweden. The armoured gunboats of the latest types cost approximately 20,000*l.* a gun. If seagoing qualities are considered indispensable, combined with a speed of twelve to thirteen knots—the speed of the monitors and armoured gunboats it should be observed is only seven or eight knots—the cost would be increased to 100,000*l.* a gun, with no other advantage than a small increase in the thickness of the armour.

On the more exposed portions of the coast seagoing vessels would be required with a speed of from twelve to thirteen knots and with considerable evolutionary qualities, with a view to the use of the ram and the offensive torpedo. The length of these vessels should not exceed 78 mètres (256 feet). If, in addition, it were considered necessary to add to the weight of the armament and to give more ample protection, considerable additions would be required to the dimensions of the ship, with a corresponding increase of the cost. It would, therefore, be necessary to subordinate one of these conflicting requirements to the other. If it were determined to increase the protection, it would be possible to have plates of from eleven to twelve inches in thickness, without exceeding the prescribed dimensions, but the protection would be limited to a belt at the water-line, and the guns would be unprotected. If it were determined to give protection to the guns, the thickness of the armour must be limited to from eight to nine inches. Of these two solutions the first should be adopted where it was contemplated to engage an enemy at close quarters; and these considerations led the Minister to regard the ram as the type best adapted for the defence of the coast of Sweden in open waters.

The force which an enemy could bring together for the purposes of disembarkation might, it was conceived, include a force of 50,000 men and 12,500 horses, with a train of artillery. It was estimated that a deck surface of 114,000 square mètres—about 26 acres—would be required to convey an army of the strength assumed in the calculation. Taking vessels of the ordinary dimensions available for such service, no less than 308 ships would be required. The fleet of transports would probably be formed into three columns, and the perimeter of the rectangle which would be occupied by the fleet would not be less than 23½ nautical miles. Most assuredly a powerful vessel of war, if it succeeded in penetrating the rectangle, and was protected from such guns as the fleet of transports would probably carry, would inflict the most disastrous losses on the hostile flotilla.

The report referred to the unarmoured gunboats of the 'Blenda'

type, which have a length of 160 feet, beam 25 feet, with a draught of water of 9 ft. 6 in., as a most successful type for the defence of the Swedish Archipelago. They are armed with a 27-ton gun, and steam eleven to twelve knots. They were built at the very moderate cost of 23,000*l.*

The Report concludes with the following summary of the *matériel* necessary for the defence of the coasts of Sweden.

I. Small vessels to operate in the Archipelago, protected and armed with a powerful armament.

II. Fast ships, with good evolutionary qualities, partially protected, to be employed outside the Archipelago and in open waters; in other words, rams.

III. Fast seagoing gunboats, powerfully armed, of the 'Blenda' type.

IV. Torpedo-vessels.

For the rams it was proposed that the displacement should be 3,735 tons, the length 246 feet, beam 39 feet, draught of water 18 feet. The armour to consist of a 14-inch belt at the water-line amidships, diminishing to eight inches at the stem and stern. The armament to consist of two 25-centimètre, or 18½-ton, guns; the speed at the measured mile to be 14 knots. The cost was estimated at 224,000*l.* The armoured gunboats were to have a displacement of 466 tons, length 131 feet, beam 26 feet, draught of water 8 ft. 6 in.; the speed to be 8 knots; the armament to consist of one 27-centimètre, or 24-ton, gun. The cost of these was estimated to be 40,000*l.*

In the following extract from *La Marine Cuirassée*, M. Dislère gives a very similar estimate of the value of the armoured ram for the purposes in contemplation in the Report of the Swedish minister of marine. M. Dislère.

'The protection of forts,' he says, 'cannot be secured without floating defences. They can choose the moment for action, and issuing forth, generally at night, they can make their way through the blockading force. They would be inferior to the high freeboard armoured vessels in one quality alone, namely, speed; and this will only be the case as long as they are loaded with guns, which for our part we do not deem to be necessary. The ram, for coast defence, in our judgment, should not be diverted from its primary object, that of ramming. The combined effect of the weight of the ship and its speed must be irresistible, and the ram, reduced to its only weapon, the spur, relieved of the weight of its artillery and of armour-protection for the guns, rendered, in consequence, small, handy, and fast,

rushing in all directions in the midst of the blockading or bombarding squadron, rendered impenetrable by its *cuirass*, and escaping the enemy's ram by its extreme handiness, ought to be for such a squadron the most terrible adversary. The heavy guns hitherto mounted on the ram have, in our judgment, had only one effect, that of destroying unity of purpose, by requiring conditions in respect to dimensions incompatible with the true function of such a vessel. In any case the ram, whether with or without guns, has no sphere of action except outside roadsteads. If the ram be kept in harbour, like the "Tennessee" at Mobile, to fight a fleet after it has forced an entrance, it may fall an easy prey to an enterprising enemy. The ram ought to be eminently active and handy; it ought to be endowed with such seagoing qualities as to be able to go out in all weathers and attack the enemy's cruisers.'

Speech of Compiler: House of Commons, 1871.

Ever since I have had the honour of a seat in Parliament, I have been deeply impressed with the deficiency of our navy in vessels of moderate draught adapted for the defence of our commercial harbours. In 1870 I placed a notice on the paper calling attention to the subject; and in the succeeding session, availing myself of the influence so deservedly exercised on all maritime matters by my valued friend, the late Mr. Graves, I seconded a motion, which he brought forward, to the effect that it was expedient to make additional provision for the defence of the commercial harbours of this country. At that date the failure of the operations of the French fleet, owing to the deficiency of vessels of light draught adapted to coast service, was fresh in the recollection of the maritime world. Our own experience in the Baltic campaign, when a powerful fleet of line-of-battle ships and frigates was condemned to inaction for want of gunboats, and the success of the operations against the Confederates conducted by the naval forces of the United States, with a large flotilla of vessels of light draught, seemed to afford conclusive evidence of the necessity for completing our naval *matériel* with a due proportion of vessels adapted for service on the coast.

The Defence Commissioners in their Report of 1860 advised that one million sterling should be spent in aid of the land fortifications which they suggested; and they laid it down as a rule that the extreme draught of a vessel adapted for coast defence should be sixteen feet. In supporting the motion of Mr. Graves, I recommended the substitution of a certain proportion of coast service vessels for the oceangoing ironclads, on which at that date our efforts were entirely concentrated. Mr. Childers had proposed the construction of 12,000 tons of armour-plated shipping per annum. His programme

consisted entirely of large vessels; while, on the other hand, the Secretary of the United States Government in his last Report had suggested that their establishment in time of peace should include forty armoured vessels for coast defence of a tonnage not exceeding 800 tons.

The cost of vessels for coast defence is comparatively moderate. Thirty-three vessels of the 'Staunch' class could be built for the cost of one unarmoured frigate of the 'Inconstant' type, and a whole flotilla of monitors could be produced for the cost of one 'Devastation.'

Our recent shipbuilding policy.

The view adopted by the Naval Administration of that date, and since consistently adhered to, has been that coast service vessels can be promptly improvised, and that our efforts should therefore be concentrated in time of peace on those classes of ships the construction of which must necessarily occupy a long period of time. There is much to be said in support of a shipbuilding policy framed in conformity with this principle. On the other hand, the telegraph and steam have in recent years expedited the progress of all naval and military operations to such a degree that it might be found impracticable to improvise even a coast service flotilla to meet the pressing requirements of the country. It may, therefore, be urged that some moderate proportion of our expenditure should be diverted from the large oceangoing ships to the construction of coast service vessels.

Moderate draught.

It is unnecessary to insist at length on the value of a moderate draught of water for all classes of ships, so far at least as it is consistent with seagoing qualities.

M. Marchal.

In an article on the classification of the navy, published in the *Revue Maritime*, M. Marchal, arguing from the experience acquired in the war of 1870, lays it down that the sphere of operations of a ship drawing more than 29 feet of water, the average draught of the vessels which experienced such insurmountable impediments in the attempt to conduct operations in the Baltic, is diminished more than one-half, as compared with that of an imaginary ship, drawing no water, and at the same time possessed of the necessary seagoing qualities.

Rear-Admiral Baron Grivel.

In his treatise on naval warfare, Baron Grivel strenuously urges the immense importance of a light draught of water for operations in inland waters. Referring to the 'Lion' type of gunboats, he points out that a draught of nine feet of water makes them absolutely unavailable for river operations, and he shows the great advantages which might have been derived from the employment of light draught gunboats co-operating with the French armies, in resisting the invasion

of the German forces in 1870. He considers that gunboats drawing from three to six feet at the most are indispensable as auxiliaries to the navy for service on the coast, and he suggests that vessels of this description could be convoyed or towed to the scene of operations for a distance of many hundreds of leagues. The ocean voyage might be considerably facilitated by removing the guns to the large vessel employed in towing.

Mr. Wells, Secretary United States Navy.

The naval authorities of the United States have been consistently opposed to the construction of ironclads of the extreme dimensions adopted by us. Mr. Wells in his Report for 1866 observes :—

'The peculiar formation of our coasts is in itself a protection against the heavy and formidable ironclads of large tonnage and deep draught which European constructors have devised; because, except at a few points, it would be difficult for them to approach within cannon shot of our shores; and there is but a single port that they can enter from the Chesapeake to the Rio Grande. But while, in the estimation of our best naval officers, our monitor class of vessels are more than a match for the monster ironclad structures of Europe, they are of such a draught that they can enter all of our principal harbours, and are therefore peculiarly well adapted to our coast defence.'

Fraser; March 1871.

A well-informed writer, in an article contributed to *Fraser's Magazine* in March 1871, makes the following observations with regard to the strength of the British navy in coast service vessels :—

'It is in small armoured ships of light draught and high speed, for the protection of our coasts and important strategical positions in the colonies, that we now are most deficient. We have no broadside ironclad, except the five weak ships of the seventh class, which draw less than 16½ feet water; and none other, except the "Penelope," which draws less than 21 feet water. Of turret-ships, we have the four new ironclads of the "Cyclops" class ordered in August last—very efficient vessels, both offensively and defensively, but designed to have 15 feet of draught; the "Wivern" and "Scorpion," of 16 feet draught; and the "Royal Sovereign" and "Prince Albert," of 23 and 19½ feet draught respectively.'

Sir E. J. Reed, K.C.B.

Sir Edward J. Reed, in a communication addressed to the *Times*, gives the following more extended list of vessels exclusively adapted for harbour defence and coast service :—

'"Cyclops," 3,430 tons, 1,660 indicated horse-power; "Gorgon," 3,430 tons, 1,670 indicated horse-power; "Hecate," 3,430 tons, 1,755 indicated horse-power; "Hydra," 3,430 tons, 1,472 indicated horse-power; "Glatton," 4,912 tons, 2,868 indicated horse-power;

"Prince Albert," 3,905 tons, 2,128 indicated horse-power; "Scorpion," 2,751 tons, 1,455 indicated horse-power; "Wivern," 2,751 tons, 1,456 indicated horse-power; "Viper," 1,228 tons, 696 indicated horse-power; "Vixen," 1,228 tons, 740 indicated horse-power; "Waterwitch," 1,279 tons, 777 indicated horse-power.'

Returning to the writer in *Fraser*, we have the following additional observations on the same subject:—

'We cannot expect impossibilities from our naval architects, but there ought, we imagine, to be no difficulty in supplying us with vessels capable of steaming ten knots in all weathers, with a low freeboard, heavy armour, and one if not two turrets with an unobstructed range of fire. They should not exceed ten to twelve feet draught of water. By lowering the freeboard of the "Cyclops" class from 3½ to two feet of water, and dispensing, if necessary, with one of the turrets, these conditions ought surely to be attained. We want of this class of ironclads at least twenty for home service, six for the Mediterranean, six in the East Indies, one in the Straits of Malacca, six in Australia, two at Vancouver's Island, and six in the West Indies and North American station, making 47 in all. In time of peace they might be hauled on shore or on slips and preserved from decay; and those that had to be sent to foreign stations could easily be escorted to their posts, after taking out their armament for safety. In time of war they would require few seamen to manage them, their guns being worked by artillerymen or volunteers; and, apart from the enormous defensive power we should possess at home in twenty such vessels, we might, in fine weather, throw such a force across the seas, and destroy any enemy's fleet while assembling for the invasion of our coasts. With such a naval strength, capable of being rapidly increased if war broke out, it would be absolute insanity for any power to dream of invading our country; and the elaborate schemes of the War Office engineers for girdling London with a circle of earthen fortresses might be relegated to their appropriate pigeon-holes.' *Fraser.*

Ten years have elapsed since the publication of the valuable paper in *Fraser's Magazine* from which we have quoted, and the condition of the British navy in vessels adapted for the attack and defence of harbours remains substantially unchanged. The armoured vessels we have afloat largely exceed the draught laid down as essential for vessels for coast purposes. In comparing the resources of the British navy with the navies of other Powers in respect to this class of vessels, our deficiencies are conspicuous. In the Russian navy we find 24 ironclads, of which 22 are vessels of 10½ feet draught, and formidable craft for coast attack as well as coast defence, thirteen being **Comparison with foreign navies.**

of the monitor type. The American fleet contains 52 ironclads, 45 of which are of light draught and adapted to coast defence.

Advantage of light draught in Red Sea.

It is a point to be always borne in mind, that the best ships for coast defence are also the best for coast attack. As an illustration we would point to the value of such vessels as we have in contemplation for guarding our communications along the line of our great trade with the East. Numerous harbours and anchorages are to be found in the Red Sea which we might find it desirable to occupy in the event of war whether with a view to guard our own commerce, or to intercept that of an enemy. The Suez Canal could be effectually blockaded by holding the Straits of Jubal, and the operation could easily be carried out by ironclads of the smallest class and by light cruisers operating from the anchorages on the west side of the island of Shadwan.

Our unarmoured coast-service vessels.

Colomb, R.N.

Considerable progress has been made in the construction of unarmoured vessels for coast service. Indeed, our foreign squadrons are composed in undue proportions of small vessels of that class. In the Essay by Captain Colomb, R.N., to which the gold medal of the United Service Institution was awarded in 1878, we find the following analysis of our fleets in commission in foreign waters:—

'We had abroad, on January 1, 1877, 13 fleet ships; 12 frigates; 18 corvettes; 38 sloops; 16 gunboats; and 8 despatch vessels. The fleet ship varied in displacement from 10,275 to 6,010 tons; the frigate ranged from 5,152 to 3,060 tons; the corvette from 2,431 to 1,542 tons; the sloop from 1,108 to 529 tons; while the gunboats varied from 455 to 330 tons. The draught of water of the fleet ship varied from 27 feet to 23 feet; of the frigate from 24 ft. 6 in. to 20 ft. 2 in.; of the sloop from 14 feet to 8 ft. 2 in.; and the gunboat from 10 ft. 5 in. to 8 ft. 2 in.'

Powerful vessels required for coast-service.

It is not in gun-vessels, but in ships of a more powerful class with a moderate draught of water, that it has been urged that the navy most needs reinforcement. Seagoing vessels of the type we have in contemplation would be capable of rendering essential service in offensive naval warfare, and in important strategical positions on the lines of communication with our colonies and principal trading centres.

Monitors.

Turning from the draught of water to the special features of the armament and the method of mounting the guns, the 'Monitor' type, with adequate freeboard, is that which finds most general favour for coast service. A committee appointed, with Lord Lauderdale as president, to examine into the merits of Captain Cowper Coles'

system of turret armament, strongly recommended that the turret system should be adopted for vessels designed for coast defence.

Admiral Hobart.

In the contribution to the *North American Review*, to which reference has already been made, Admiral Hobart recommends small but thoroughly seaworthy monitors as the most effective vessels for harbour defence:—'As regards America, if I might venture to give an opinion, I would say that, if, in each of her fortified seaports, such as New York or Boston, three or four small monitors, and a dozen or two of torpedo-boats, were stationed, the inhabitants might sleep quietly in their beds,—more so, indeed, than the crews of the enemy's ships outside the port. When I say monitor, I refer to vessels with high freeboards, mounting four guns in fixed batteries (tonnage about 1,200 tons). The reason I say high freeboards is, that such vessels might be able to go to sea at any moment, regardless of the weather, thus depriving the enemy of that repose which bad weather so often brings in naval operations. The vessels I suggest should be similar to those built for the Turkish Government by the Thames Iron Works, and Messrs. Samuda on the Thames, at the cost of about 125,000*l.* each, including guns; thus five of them could be obtained for the price of one such huge sea-monster as the "Inflexible."'

'Gorgon' class.

As we read Admiral Hobart's warm eulogy of the small monitors constructed for the Turkish Government, it is with regret that we see postponed from year to year the great improvements in the 'Gorgon' class by the additional superstructure so strongly recommended by the Committee on Designs and by the Constructor's Department, with a view to secure a greater range of stability. The value of such an alteration was apparent during the Russo-Turkish War, when great efforts were put forth to make an imposing demonstration of our naval resources. The squadrons of Admiral Hornby and Admiral Key were certainly superior to any possible combination of naval powers with which they could have been called upon to contend; but they were not so fully prepared as might have been desired for every exigency. The main deficiency was in vessels of moderate draught specially adapted to coast service. Improved vessels of the 'Gorgon' class would have been most valuable in the Baltic and in the narrow waters of the Dardanelles and the Bosphorus.

Siege of Fort Fisher.

The superiority of the monitor type over every other for the naval attack of a fortress was signally illustrated on numerous occasions in the Civil War in America. The siege of Fort Fisher, Wilmington, is described by Captain Bridge, R.N., as the most re-

markable operation of the kind which has been undertaken in modern times. The parapets of the fort were 60 feet in thickness, and its casemates contained 36 of the heaviest guns. The attack began on Christmas Day 1864. During twelve hours the monitors, at a distance of a thousand yards from the fort, rained upon it a shower of their enormous 13, 14, and 15 inch projectiles. The experiences of the combat establish the incontestable superiority of the monitors.

Major Parnell, R.E.

As a general summary of the qualities required in ships for coast service, we give Major Parnell's enumeration of the main characteristics to be desired in vessels designed for the operation of a naval attack :—

(*a*) Small draught.

(*b*) Broad beam.

(*c*) Great stability.

(*d*) Low freeboard.

(*e*) Short and handy.

(*f*) Double-ended, with a screw and rudder at each end, on Griffiths' principle.

(*g*) Two independent sets of engines and boilers.

(*h*) No masts.

(*i*) Fair horse-power.

(*j*) Great thickness of vertical armour, especially at the vital parts.

(*k*) Protection against curved and plunging fire, by deck and horizontal armour-plating.

(*l*) Protection against sinking, by numerous well-arranged water-tight compartments.

(*m*) The heaviest guns, and not more than two of them.

(*n*) The guns to be mounted, as desirable, either in a moveable turret, a fixed turret, or a box-battery, but, in any case, to be capable of delivering a simultaneous bow-fire.

(*o*) Fair coal-capacity and steaming endurance.

(*p*) Good accommodation for crew.

The monitor is, *par excellence*, the best type of vessel for the operations of naval warfare on the coast. Its zone of action will embrace all European seas, and with the additional coal-supply of the large English turret-ships the Atlantic may be crossed. The main defect of the Monitor type is in respect of habitability at sea : and it is not proposed that such vessels should be called upon to make extended cruises.

Sir E. J Reed, K.C.B.

A wise and economical plan of supplying ourselves with the means of creating a numerous flotilla of gun-vessels was suggested

by Sir Edward J. Reed in the paper read at Birmingham in 1871, from which we have already made extracts. It contains the following valuable suggestions :—

'We have at our hands abundant material and labour for turning out an enormous number of small-size coast defence vessels in an extremely short time, provided two conditions are carefully and thoroughly fulfilled. These two conditions are—first, the perfect readiness of all our plans and arrangements for the production of these vessels, even down to the minutest details; secondly, the construction beforehand of those sterns, stern-posts, engine-shafts, and other parts of the vessels which necessarily take a considerable time to produce, and which no amount of labour and no expenditure of money can possibly produce quickly. While I would give each large port, as already suggested, the advantage of one or two light-draught armourclads, I propose that our principal naval coast defence shall consist of unarmoured vessels. . . . If an enemy brings his ironclads to your ports, he gives you certain advantages, of which you would be most foolish not to avail yourselves. One of those advantages is that you may send out against him vessels which, not being required to keep the sea, with all its risks, need not be encumbered with the thousand and one things which seagoing ships must usually carry. And I think one of those things is armour. Have, as I say, one or two light-draught armourclads at the principal points of the coast, to lead and hold the hostile squadron as may be necessary, but let your great attacking force consist of a number of small and light vessels, carrying in some cases a very heavy gun, in others lighter guns, with flat-fronted shell for penetrating below water, and in others torpedoes, and I venture to say that by these means you will dispose of your enemy even more effectually than by any other means whatever. The more I reflect upon this subject the more clear and strong my conviction becomes, that the thorough and effectual defence of our ports is much more a question of mind and forethought, brought to bear upon our ample resources, than of great constructions and lavish expenditure.'

In a paper read by Mr. Barnaby at the 20th Session of the Institute of Naval Architects, we find an entire concurrence with the recommendations put forward by Sir E. J. Reed at Birmingham. Mr. Barnaby agrees that the siege fleet and the harbour of defence fleet should consist mainly of light and handy and inexpensive vessels, which can be produced by a nation possessing our unrivalled resources at comparatively little cost, and in as few weeks as it takes years to build our ponderous ironclads. Contrasting the methods of naval Mr. Barnaby.

warfare in 1879 with those adopted in 1854, and looking to the increasing power of the guns and the growing importance of the offensive and defensive torpedo, Mr. Barnaby drew a conclusion distinctly adverse to the extended construction of armoured batteries such as those of 1854, which are at the same time 'exposed to destruction by the torpedo defences of the port as well as by its guns, while the *flotte de siége* of 1854 is useless against the guns of the ports and defenceless against their torpedoes. It would, perhaps, have saved the expenditure of millions of money, if the Council of Ministers who met to consider the Emperor's message had proposed a *flotte de siége* consisting of small unarmoured gunboats of eight or ten knots' speed, mounting guns of greater range and power, instead of proposing to mount the existing guns in protected ships. Such a siege fleet would have met the necessities of to-day as well as those of 1854.'

Mr. Barnaby took another opportunity of expressing his high appreciation of the value of economical means of harbour defence in his paper on *Modern Ships of War*, read at the United Service Institution on the 29th of January, 1872. 'I am,' he said, 'of opinion that when we desire to organise "special coast defence," it can be done far more efficiently and cheaply than by an increase in the number of such ships as the "Glatton" and "Cyclops," excellent and powerful as they are. I consider that the "Cyclops" is nearly perfect as a ship of the particular type desired; and when the superstructures are added, they may be safely navigated to any part of the world. But, when designing for "coast and harbour defence" comes to be fairly considered, I am quite sure that the problem admits of an easy and comparatively inexpensive solution.'

Commander Hayes, R.N.

Naval writers agree with Sir E. J. Reed and Mr. Barnaby that it is not necessary to complete a large flotilla of gunboats in time of peace. They think with them that it will be an important gain if those parts of the structure the production of which will occupy the longest time are prepared beforehand to meet the exigence of war. Commander Hayes, the writer of a successful essay in competition for the prize awarded by the Royal United Service Institution, expresses his views as follows:—

'The gunboats or floating gun-carriages of the "Snake" class will be invaluable in the attack and defence of coasts and rivers. It will probably be necessary to greatly increase their number and size, the Chinese gunboats ("Gamma" and "Delta") being good specimens of the boat required. Mr. Reed's suggestion of forging stems, stern-posts, and other heavy forgings for vessels of this class, seems to be

most valuable; perhaps the same stem and stern-posts would do for modified forms of gunboat; it is a question whether we should have time to put them together in case of sudden invasion, but for any other case of war they would be ready in time.'

The opinions of our most eminent naval constructors are fully shared by artillerists, naval officers, and naval architects, who have studied the subject of coast defences and coast attack from an independent stand-point, free from departmental influences. No change in the state of professional opinion can be traced as we come down in historical order from the earliest to the latest utterances on the subject.

In his *Treatise on Naval Gunnery* Sir Howard Douglas stated that: 'For the bombardment of a naval arsenal, the 13-inch mortar is a most valuable piece of ordnance; and, as its transport by sea is neither so difficult nor so costly as by land, the considerations which prevent, or impede to a great extent, the employment of these, and of 10-inch mortars, in the land service, are not sufficiently cogent to warrant the disuse of such ordnance in naval expeditions. It appears to the author that a large fleet fitted out specially for the purpose of bombardment, should be provided with a certain number of bomb-ships. These are very inexpensively furnished, draw little water, and may be towed to their fighting positions by small steam-tugs: an officer and a few marine artillerymen suffice for the service of the mortars; they are also small objects for the enemy to fire at; and, if destroyed, there is comparatively little loss in value, and small risk of life. Seven bomb-ships were attached to the Baltic fleet in 1801, and, from these, at the time of forcing the passage of the Sound, shells were thrown into Cronenberg with considerable effect, while the fleet sustained no injury whatever from the enemy's guns. Admiral Nelson made use of those bomb-ships at the battle of Copenhagen, and to this bombarding power was greatly indebted in bringing those very critical operations to a successful termination. In the British naval service, though bomb-ships no longer exist, 13-inch and 10-inch sea-service mortars are retained: from this it appears that horizontal or howitzer shells fired from the pivot-guns of steam-frigates are supposed to be efficient substitutes for mortars in bombardments of fortresses and naval arsenals: but this is not so; and therefore to employ large and costly steamships in this way, is to incur a risk of very great loss in property and life, without the power of accomplishing the peculiar conditions required in bombardments, and which mortar-shells can so much more effectually fulfil.

Sir Howard Douglas.

Speaking at the United Service Institution early in 1871, Admiral Scott said:—

Rear-Admiral Scott.

'I think the "Staunch" is rather too small for her intended service. We want a vessel of similar type, but capable of carrying the heaviest gun, viz., a 25-ton or 35-ton gun; she must therefore be somewhat larger than that vessel is. Not only should she be able to protect our own shores, but she should be also able, if it were requisite, to carry her guns across to the neighbouring shores. I think the power of England depends upon offensive power much more than upon defensive. We want more vessels of the "Monitor" type, and a great many more "Staunches." Instead of a few of such vessels having been ordered to be built, we ought to have already built a hundred.'

General Schomberg.

In the discussion at the United Service Institution on the Naval Prize Essay, on March 30, 1876, General Schomberg said:—

'My idea of a gunboat for the defence of the coast of England is a vessel that can take the sea in any weather and carry the heaviest guns—I do not mean the monstrosities in the way of guns we are now trying, but 35-ton guns. Such vessels as could also keep the sea and rendezvous off Beachy Head or the coast of Ireland in any weather are what we require.'

Commander Dawson, R.N.

Commander Dawson spoke to the same effect.

'A ship for the coast defence of England must be far more seaworthy than if she had to go abroad. What we want, however, is not a special class of vessels for inland waters, that is, to cost 300,000*l.* a-piece; it is not a single costly vessel of limited usefulness at the mouth of the Thames. What we want is a multitude of seagoing and sea-keeping gun-vessels; the smaller the better; the heavier their guns the better; but they should be vessels which can go anywhere and in any weather, and not be caught. Having very shallow draught of water, such vessels could go over the banks into shoal water, where they could not be run down by deep draught ships, which could not go there. Shoal water would, therefore, be a place of safety to vessels of this class.'

Mr. Scott Russell.

Mr. Scott Russell has been consistent in his faith in the capabilities of small gunboats. In his elaborate volumes on naval architecture he gives numerous examples of the earlier attempts to combine great offensive power with small tonnage. He gives drawings of an iron gunboat built by Messrs. Rennie for the Spanish Government, which was one of the earliest of the class of gunboats propelled by the double screw. She is propelled by fixed horizontal engines, of a united power of thirty horses. In this little boat Messrs. Rennie have shown the way to the practicability of constructing iron gun-vessels

of very small size and very light draught of water: Tonnage, $85\frac{6}{94}$ tons; draught of water, 2 ft. 6 in.

He also gives drawings of a still smaller class of gunboat, partially protected by iron armour, and mounting one large gun on a pivot-slide. This vessel has partial protection by plates of armour fore and aft, is intended to engage only one end on, and the iron bulkhead in the front rises up through the deck and gives protection against horizontal rifle and shell fire. The engines are double screw engines, and the vessel is designed for a speed of eight knots:—

Draught of water	4 ft. 6 in.
Displacement	211 tons
Weight of armour	47 tons
Weight of guns and ammunition . . .	12·5 tons

In his paper read at the Royal United Service Institution in June 1877, on *The Development of our Modern War Ships*, Mr. Scott Russell gave utterance to the following strong opinion of the value of small vessels in naval warfare:—

'I rank the gunboat, with one big-bore gun, as the class of war vessel next in importance to the ship of the line. . . . Assuming that this one-gun vessel is taken as our unit, and that her gun has 15 inches bore, and 18 or 36 tons weight, the vessel herself will have to be not less than 25 feet beam, and probably more than 150 feet long.'

The 'Nancy Dawson.'

A still cheaper means of defending coasts and harbours has been from time to time adopted in active warfare; we refer to the rafts such as the 'Nancy Dawson,' constructed by Captain Cowper Coles for operations during the Crimean War in the Sea of Azov. The nature of the approaches to many of our most important harbours is such as to admit of the practicability of mounting heavy guns on rafts, which could be towed into their designed positions by gunboats with great manœuvring capabilities. An effective river flotilla should include vessels capable of being manœuvred, combined with others which possess no such capability.

On the general question of the combination of fixed and floating defences, consisting of rams, monitors, gunboats, and torpedo-vessels for the purposes of coast service and harbour defence, the following opinions have been brought together from foreign writers of authority:—

Baron Grivel.

In his interesting volume, *Mission Militaire et Nouveau Programme de la Flotte*, Baron Grivel gives a description of two new

coast defence vessels, the 'Tonnerre' and the 'Tempête. The following are their principal dimensions :—

	Tonnerre	Tempête
Displacement	5,584 tons	4,523 tons
Draught	$21\frac{2}{3}$ feet	$16\frac{2}{3}$ feet
Thickness of armour at the water-line .	13 inches	13 inches
Speed at measured mile	13 knots	10 knots
Complement	160 men	150 men

Baron Grivel considers these coast defence vessels as far superior for fighting purposes to the 'Bélier' type. On the other hand, he regrets the necessity for increased displacement. The 'Tonnerre,' from its speed and draught of water, he regards as the type of a *navire de sortie*—a vessel capable of defending great commercial ports. The 'Tempête' represents, on the other hand, the coast defence vessel, which should be employed to protect the inner waters or roadsteads. In both types, he points to the fact that, from the force of circumstances, and the necessity for carrying armour, the displacement is very large, from which it inevitably follows that the cost is increased.

Comparing the 'Bélier' and the 'Tonnerre,' both of which vessels may, from their speed, claim to be classed among the *navires de sortie*, we find that the superior qualities of the larger vessel are secured by means of an increase of 2,000 tons in the displacement, and an increase in the draught of water of 3 ft. 11 in. In the case of the 'Tempête,' the displacement exhibits an increase of 1,000 tons over that of the 'Bélier' type.

Commenting on these figures, Baron Grivel expresses his general view of the types best adapted for coast defence in the following terms :—

'Aussi longtemps qu'on croira indispensable pour les gardes-côtes d'être revêtus d'un cuirassement efficace, il ne paraît guère possible d'obtenir des types à meilleur marché et tirant moins d'eau que la "Tempête." Mais un prix de revient élevé, et une fonction du déplacement, entravera toujours la multiplication de l'espèce.

'Si, au contraire, l'on arrivait à se convaincre que le nombre des éperons et le tirant d'eau très-réduit sont, pour la défense mobile des ports, des éléments de succès indispensables, dès lors, il faudrait étudier de nouvelles combinaisons.

'Nous ne serions donc pas surpris que, dans l'avenir, on en vînt à faire la monnaie des types actuels, c'est-à-dire de construire de petits béliers en bois, sans cuirasse, sortes d'éperons flottants, ayant tout juste le M.V^2. nécessaire pour enforcer le flanc d'un navire ennemi.

'Le mérite principal de ces éperons flottants serait de tirer très-peu d'eau (9 à 10 pieds), de n'exiger qu'un déplacement sans doute inférieur à 1,000 tonneaux. A ce compte, et à ce prix, on pourrait multiplier ces défenseurs des eaux intérieures au niveau de tous les besoins. Un seul gros canon serait établi derrière un masque à sabord.

'Ce bélier à bon marché irait tout simplement s'échouer, en cas de voie d'eau menaçante, sur une plage favorable. Une vitesse de 8 à 9 nœuds lui suffirait.

'La barre et le commandement auraient une guérite un peu élevée à l'abri de la mitraille.

'Ces béliers à bon marché seraient en même temps des canonnières de défense intérieure. Attaquant un ennemi dans les directions différentes, à la façon d'une meute, avec les torpilles à la remorque, à notre sens, leur mobilité et leur nombre en feraient des adversaires redoutables.'

A paper was read by Mr. Hamilton at the United Service Institution in 1868 on the operations of the American Civil War. He concluded with the following condensed statement of the lessons to be drawn from the most extended series of operations in coast warfare that had ever been undertaken. Mr. Hamilton.

'1st. Fixed fortifications without obstructions are powerless under ordinary circumstances to prevent the passage of a swift and powerful fleet.

'2nd. Floating batteries to fight such a fleet must be quicker in turning, of light draught, and unexceptionable rams.

'3rd. The placing of one or two floating batteries in a harbour, and depending on them to destroy a fleet which is capable of passing a regularly constructed fort, is but an invitation to disaster, and a delusion which should be dispelled by the fate of the "Tennessee" at Mobile. Under similar circumstances it would perhaps be safer to rely on a fleet of nimble musquitoes, like the "Staunch," with their 300-pdr. stings, than upon an invulnerable, but sluggish ironclad battery.'

It has already been observed that we have made satisfactory progress in recent years in the creation of a flotilla of gunboats.

Twelve gunboats have recently been constructed which were specially designed by Mr. Henry Morgan, one of the Chief Constructors of the Admiralty, for service on the rivers of China, but which are equally adapted for effective service in European waters. These vessels have been named after the English rivers, and may, therefore, be described as the river class of gunboats. Nine were engined by Messrs. Hawthorne, of Newcastle, and the remainder by Messrs. John River gun boats.

Penn, of Greenwich. Their displacement is 386 tons, and their engines are constructed to work up to 310 horse-power. They are twin screws, 110 feet long by 34 feet broad; the great breadth of beam in proportion to the length being a practical acceptance on the part of the Constructive Department of the views of Mr. Froude with reference to the resistance of wave motions to the speed of ships. Their speed at the measured mile is 9·5 knots. They are of light draught, 5 ft. 8 in. forward, and 6 feet aft, and they are provided with bow as well as stern rudders. They are built of iron, but fitted with a false wooden keel and cased with wood from bilge to bilge, with an outer sheathing of zinc. In mid section they present the shape of an elongated oval, the sides of the hull projecting several feet beyond the stanchion bulwarks. The steam for the engines is furnished by two boilers separated by a bulkhead having a watertight door. The boilers are placed longitudinally along the ship instead of transversely, so that more room is provided for the stokers and ventilation. The bunkers are situated on either side within the wing bulkheads, and possess unusual storage capacity. The armament consists of three revolving 64-pdrs., two at the bows, protected by a topgallant forecastle, and one at the stern, and two Gatling guns at the waist. The gunboats have three masts, with a fore-and-aft rig, and will carry about 40 men each.

The chief objection to our river class of gunboats for the particular service for which they were intended, consists in the fact that, being constructed entirely of iron, they will require special care in matters of ventilation in hot weather.

The river gunboats have been appropriated for several years for the annual drills and cruises of the Royal Naval Artillery Volunteers. Two vessels of this class have lately performed in a satisfactory manner the long voyage from England to Hong Kong. It cannot be doubted that vessels of this type would render most excellent service in the event of warlike operations being undertaken in shallow waters. They were not designed for the ordinary duties of the police of the seas. Our more recent sloops and corvettes are admirably adapted for this service, and the tendency is to increase the number of vessels of those classes in commission, and to keep the gunboats in reserve for the special purposes for which they were intended.

Sir William Armstrong's gunboats.

Having described some of the more recent types of gunboats constructed fo our own service, it may be convenient to turn to the latest types constructed by our private shipbuilders for foreign Governments. The most remarkable vessels of this class are those which have been built by Messrs. Armstrong, of Newcastle-on-Tyne,

for the Chinese Government. The first examples of the Chinese gunboats, named the 'Alpha' and the 'Beta,' have a load displacement of 325 tons, with a draught of 7 ft. 6 in., and they carry each a gun of 27 tons. These vessels made the voyage to China most satisfactorily, accomplishing the passage from Aden to Point de Galle, a distance of 2,100 nautical miles, without a break, and carrying their guns and ammunition on board. The 'Gamma' and the 'Delta,' the next two vessels of the series, have a length of 115 feet; beam, 30 feet; draught, 8 feet, with a freeboard of about 3 feet. Their load displacement is 430 tons, and their speed under steam 9 knots an hour. Each vessel carries 50 tons of coal in the bunkers. The vessels are of iron, and built with numerous compartments. The engines are below the water-line, and the boilers, though somewhat more exposed, are protected by coal armour. The economy of fuel is such that, under ordinary conditions of weather, these vessels could steam a distance of 1,500 miles. They are fitted with two tripod masts, and are propelled by twin screws. Each gunboat carries in the bow a muzzle-loading Armstrong gun of 38 tons, loaded and worked by Mr. George Rendel's hydraulic gear, and capable of penetrating 19½ inches of wrought iron in three layers, with teak of an aggregate of 10 inches between the plates. The power and range of the Armstrong 11-inch muzzle-loader is 15 per cent. over the power of the guns mounted on board the 'Dreadnought.' The 'Gamma' and 'Delta' are unarmoured, with the exception of a shield to protect the crew from rifle bullets at the bow. In addition to their large gun, they carry two 12-pounder broadside breech-loaders at the stern, and a Gatling gun.

Four gunboats of a still more formidable type, and named respectively the 'Epsilon,' 'Zeta,' 'Eta,' and 'Theta' have recently been delivered by the firm of Sir William Armstrong to the Chinese Government. The more important particulars relating to these vessels are given in the subjoined table. It should be mentioned that the material employed in the construction is steel.

Sir William Armstrong's gunboats.

Principal dimensions—

Length extreme	127 feet
Length on water-line	125 feet
Breadth, moulded	29 feet
Depth	12 feet 3 inches
Draught of water	9 feet 6 inches
Displacement	about 440 tons

Engines, collective nominal horse-power about 70, to indicate 380 horse-power.

Speed of vessels—

Forwards	10 knots per hour
Backwards	9 knots ,,

Rudder at each end.

Two pairs of compound engines driving separate screw-propellers.

Engines, boilers, magazine, shell room, &c., all under water-line.

Four transverse watertight bulkheads, horizontal under-water deck over magazines, also longitudinal central bulkhead forwards of engine.

Rifle screen for the gun.

Accommodation for 27 men besides officers.

Armament consists of one 35-ton gun firing forward. The vessel being double-ended, this gun may be regarded as a stern-chaser when the vessel is going backwards.

The gun is of the new Elswick type, and fires a battering charge of 235 lbs. pebble powder. The gun is worked, loaded, and controlled by hydraulic power, and requires only five men.

Two 12-pdrs. of the new Elswick type are carried on the quarter, charge 3 lbs.

And two Gatling guns for which sockets are provided in different parts.

Tripod masts of iron.

Bunker capacity, 70 tons.

Coal-consumption at full speed about half-a-ton per hour.

Method of training guns. The method of training the guns in these small gunboats has been seriously criticised by high authorities, who doubt the possibility of accurate training when reliance is placed entirely on the rudder and the action of the twin screws.

Mr. King, in his recent volume, makes the following observations on the 'Gamma' class:—'Extravagant estimates of the merits of this class of vessels have been formed. They are not free from objections, one of which is the want of lateral movement of the gun without moving the vessel, and, in order that they may act with maximum efficiency, the water must be tolerably smooth; and at such a time it would not be difficult to hit one of them by a shot from the small rifled guns carried by armoured ships, and send her to the bottom. Therefore, except under peculiar circumstances, they are useful for defensive purposes only, and service on board of them must in many cases during war be attended with extreme risk.'

The Chinese gunboats certainly appear too vulnerable to be armed with a 38-ton gun. Three 'Comets,' each carrying an 18-ton gun, can be built for the cost of one 'Epsilon.' The inference is that the 'Comet' is the best type.

Admiral Scott. In a discussion on this subject at the United Service Institution, on June 8, 1877, Admiral Scott made the following observations:— 'With respect to Mr. Scott Russell's mode of mounting his standard 36-ton gun, and making the vessel the means of pointing it, I feel

quite sure he makes a great mistake. I have tried to point guns by means of the helm, but always found that just as the man was going to fire, the ship gave either a slight roll or lurch, or else a swing, and disturbed the aim. To point and fire a gun fixed in the bow, she must keep advancing, otherwise she cannot fire. To remedy this defect in part our 18-ton gunboats are arranged to give their guns 25 degrees of training on each bow, but that is not enough, because the gunboat can only fire when it is approaching an enemy. What you should do is to make any new gunboats a little larger, so as to admit of their heavy ordnance being given a wide arc of training, using appliances as simple as possible. We can work guns up to 50 tons weight by hand appliances, but I do not think we can go beyond that with advantage; in fact, I think, properly rifled 40-ton guns would be fully equal to doing our naval work.

The views of Admiral Scott were confirmed by Sir John Commerell. 'As to the gunboats themselves being carriages for the guns, I am afraid,' he says, 'that they would not answer. In advancing up rivers you would have, no doubt, to engage an enemy on the banks, and at any attempt to turn to port or starboard the current would catch the bow and, the chances are, would take you on shore. I would infinitely sooner see the size of the gun sacrificed to a certain extent if we had a good carriage, so that the gun should have a fair angle of training.' Sir John Commerell, K.C.B.

The following observations with reference to the cost of these gunboats are taken from the *Broad Arrow* of August 29, 1878:— *Broad Arrow.*

'And now that we have stated, somewhat briefly, it is true, what these gunboats are capable of doing, let us inquire a little respecting their cost. Sir William Armstrong offers to supply them at 35,000*l.* a-piece, so that we may reckon their real cost of production at a lower figure still. It should be observed that 35,000*l.* includes hull, machinery, rigging, guns, and appliances. If the Admiralty possessed the plans and were to invite tenders throughout the country for building them, we feel sure they could be had for less than 30,000*l.* each. In saying this we do not deny the undoubted right of the inventor of this type of vessels to obtain ample reward for his abilities and labours. Now compare 30,000*l.*, or even 35,000*l.*, with the cost of an "Inflexible." We are told in the Navy Estimates that the last-named vessel is to be built for 500,000*l.*; but we very much question whether 600,000*l.* will pay the bill by the time she is ready for sea; and even that sum does not include her stores and armament. Of course we do not pretend to say that an "Epsilon" is equal to an "Inflexible," but we do say that an "Inflexible" is a

long way from being the equal of seventeen "Epsilons." Let us picture one of our huge ironclads surrounded by eight or ten of these mosquitoes. Here we have, say, eight 35-ton guns, each capable of penetrating seventeen inches of armour at a thousand yards, and so distributed that by being kept continually on the move it is difficult, if not impossible, for the four guns of the ironclad to hit them. They can go safely into two fathoms of water, while the ironclad is scarcely safe to move in five fathoms.'

M. Lebelin de Dionne.

Among foreigners who are in favour of a certain addition to the dimensions of our gunboats, with a view to carry out the improvements advocated by Sir John Commerell I may more particularly refer to M. Lebelin de Dionne. In the debate on the Naval Estimates for 1879 he assured the members of the French Chamber that the course taken by the French constructors in producing a class of gunboats similar to the 'Coquette' type in the British service, but with somewhat larger dimensions, had been entirely approved by the French naval officers.

In addition to the gunboats constructed for the Chinese Government by Messrs. Armstrong, gun-vessels armed with one powerful gun have been constructed by Messrs. Laird for the Argentine Confederation, and by Messrs. Rennie for the Peruvian Government. Messrs. Laird's gunboats carry a gun exceeding the weight of 20 tons, and Messrs. Rennie's gunboats, though little larger than our own 'Staunch' type, carry a 26-ton gun.

Proposals for creating a coast defence and coast service fleet.

Having described the nature of the defences, fixed and floating, which are recommended for coast and harbour defence, the following may be suggested as the practical conclusions which should be followed by the Naval Administration of our own country: I. A few effective monitors can be built at a moderate cost by the conversion of the 'Gorgon' class, as suggested ten years ago by the Constructor's Department. The opportunity of carrying out the improvements recommended will offer itself when the present boilers cease to be effective. We may refer to the recent conversion of the 'Hotspur' as an illustration of the work which might be carried out with great advantage in the improvement of the 'Gorgon' class. II. The 'Polyphemus' will doubtless be a most formidable vessel, but the extreme costliness is a serious objection to the type. We require for the Navy a handy vessel capable of steaming seventeen knots, with good seagoing qualities, and protected by a horizontal deck, but without an armour-belt at the water-line. The upper works not being armoured, could be raised to any height that might be necessary to afford good accommodation for the crew. The conning-

tower should be lofty and machine-gun proof. The internal structure should be simplified. The torpedo-tube in the stem should be omitted. An ample armament of machine-guns should be provided. Such a vessel could be built at considerably less cost than the 'Polyphemus,' in which every feature has been experimental. III. Gunboats in considerable numbers are essential. We are satisfactorily supplied with river service gunboats in consequence of the recent construction of twelve so-called river gunboats. It would be desirable that one of these should be stationed for drill purposes at each of our principal seaports. Preparations could be made for the multiplication of similar or superior vessels in numbers by the adoption of the suggestions of Sir Edward Reed and Mr. Barnaby. IV. Our Mercantile Marine might be utilised for the purposes of naval defence. Our tug and coasting steamers would be most valuable vessels for harbour defence. They might easily be fitted to carry a gun mounted on Admiral Scott's plan, so successfully applied in the 'Staunch.' V. The recently established force of Royal Naval Artillery Volunteers would find their appropriate sphere of duty in manning the gunboats and auxiliary vessels at the mercantile ports.

CHAPTER VII.

HISTORICAL SKETCH OF NAVAL EXPENDITURE SINCE TRAFALGAR.

Review of Navy Estimates.

THOUGH the naval superiority of Great Britain may be considered as having been definitely established by the crowning victory of Trafalgar, it was not till after the final completion of the war with Napoleon that the expenditure in the Navy was permitted to sink to what may be assumed as the normal peace amount. For the service of the year 1806, 91,000 seamen and 29,000 marines were voted; and the sum required was 18,864,341*l.* In the next year, 1807, the number of men was increased to 130,000; but the money voted was reduced to 17,400,337*l.* For 1810, 1811, and 1812, the number of seamen in the Navy was increased to 145,000; and though these were reduced in 1814 to 90,000, the average annual expenditure was about nineteen millions until the final conclusion of the general peace. In 1816, the Navy Estimates were fixed at 10,114,345*l.*, a figure which they never reached again until we were at war with Russia.

In 1855 the estimates were raised to 14,490,105*l.*, and in the following year to 19,654,565*l.* For 1857 they were raised to 20,811,242*l.*, the highest figure at which they have ever stood during the period under review. The effect of the declaration of peace is apparent in the diminution of the estimates for 1858 to a total of 12,915,156*l.* For 1859 the figures were further reduced to 12,512,290*l.* From this reduced standard the estimates were once more raised, owing to the universal introduction of steam, and the construction of the ironclad ships which we were compelled to furnish for the navy. For 1860, 1861, and 1862 the estimates were 14,057,186*l.*, 14,970,000*l.*, and 12,598,042*l.* From 1862 to 1869 a total of eleven millions may be taken as the average annual expenditure.

In that year the Navy Estimates showed a noticeable reduction, the amount having fallen to 9,403,835*l.* In 1874 they again rose to more than ten millions. For 1876, and again for 1878, including

the special charges, they stood at more than twelve millions. Judging from recent votes, ten millions and a half may, perhaps, be taken as the average and normal amount in time of peace. The several fluctuations which have been noted are almost entirely in the sums which relate to the *matériel*, or more exactly in those which relate to additions to it. Since the general form and constitution of modern navies has been established, the money necessary for their maintenance at the normal standard has not been found to vary considerably.

Shipbuilding votes the principal cause of fluctuations.

'The most important feature in naval expenditure is the provision for the construction and repair of ships.' 'The naval policy of the past ten years,' said a writer in the *Times* in 1880, 'so far as it may be measured by naval expenditure, is governed by the ship-building arrangements which have been approved from time to time. In other words, the rise or fall in the annual cost of the navy, or in the estimates presented to Parliament, is coincident with the rise or fall in the shipbuilding expenditure.' This will be seen when the following figures, for the period from 1869 to 1878, are examined:—

Year	Total Amount of			Variation in	
	Expenditure on Ships	Votes 6 and 10 (Labour and Stores)	Navy Votes	Ship Expenditure	Navy Votes
	£	£	£	£	£
1869–70	1,964,339	2,572,745	10,102,641	—	—
1870–71	2,000,430	2,635,076	10,087,414	+ 36,091	– 15,227
1871–72	1,669,109	2,545,865	9,875,981	– 331,321	– 211,433
1872–73	1,355,003	2,413,347	9,564,678	– 314,106	– 311,303
1873–74	2,106,010	3,175,631	10,558,751	+ 751,007	+ 994,073
1874–75	2,520,960	3,455,650	10,776,277	+ 414,950	+ 217,526
1875–76	2,566,895	3,540,092	10,903,924	+ 45,935	+ 127,647
1876–77	2,929,616	3,929,846	11,259,835	+ 362,721	+ 355,911
1877–78	3,991,867	5,123,591	12,800,044	+ 1,062,251	+ 1,541.209

'From the above statement it is apparent,' says the writer already quoted, 'that, except in the year 1870, the increase in the naval expenditure or in the navy votes was coincident with a proportionate increase on the expenditure on the construction, maintenance, and repair of our fleet.'

The ships of the present day in either the fighting or the commercial navy are much more costly than those which were thought good enough, and perhaps really were good enough, for the requirements of the time twenty years ago. All maritime states are beginning to discover 'the gradually increasing cost of ironclad construction. The average sum of half a million sterling no longer covers the cost of a modern ironclad.' The hull of the 'Inflexible'

alone, it was estimated, was to cost for labour and materials 576,000*l.* If the cost of the machinery be added, the total does not fall below 700,000*l.* The cost of the latest Italian armourclads exceeds even this prodigious sum. While the prices of skilled labour and of the material which enters largely into the construction of the modern armoured ship of war have advanced, there has been a corresponding addition to the appliances with which she must be provided to ensure efficiency. If we look back ten years, an ironclad was held to be admirably equipped and thoroughly fit for any possible service, though she had not a single machine gun, Whitehead torpedo, or electric light on board. She would not now be permitted to go to sea, were there even a remote chance of meeting an enemy, without a proper supply of all these things, and of many other costly fittings which have been introduced into the navy since the Franco-German war. New guns, designed in accordance with the requirements of the navy in view of the progress made in foreign fleets, and the novel steel-faced armour will be found in all ships to be built in future, and will, no doubt, in many cases supersede older weapons and less efficient armour in some of those already afloat. They cannot, however, be provided without a considerable advance on the cost of those that have hitherto been considered sufficient.

The introduction of steam is an inevitable cause of an increase of expenditure as compared with the period when our floating material was composed of sailing ships. It has been disputed that the cost of coal used in navigation in any year exceeds that of the wear and tear due to the exclusive employment of sails. But the equipment of a ship with engines and boilers results of necessity in the expenditure of certain sums for repairs which are, of course, in excess of those required for the proper maintenance of the hull and the more purely warlike equipment. Moreover, the obligation of periodically renewing the boilers is a source of great expense, and accounts almost entirely for the large figures which appear in official reports of the repairs done to ships of war. In 1877-78, the 'Monarch' cost for repair 79,972*l.*; the 'Invincible,' 74,433*l.*; the 'Hercules,' 67,409*l.*; and the 'Iron Duke,' 45,727*l.* As the present writer pointed out in a letter to the *Times* of April 7, 1880:—'Iron hulls, when properly cared for, possess great durability; but boilers deteriorate rapidly, and considerable sums are constantly being expended in alterations in the rig, the armament, and the fighting equipment.' In fact, it has often happened that the expenditure on what is officially designated 'repairs' was in reality incurred in carrying out alterations in the equipment which converted the ship into an efficient man-of-war.

APPENDIX.

TABULAR SUMMARY OF NAVY ESTIMATES.

Year	Estimate	Seamen and Marines.
1806	£18,864,341	120,000
1807	17,400,337	130,000
1808	18,087,547	130,000
1809	19,578,467	130,000
1810	18,975,120	145,000
1811	19,822,000	145,000
1812	19,305,759	145,000
1813	20,096,709	140,000
1814	19,312,070	90,000
1815	19,032,700	90,000
(Two millions of the navy debt paid off).		
1816	£10,114,345	33,000
(First year after the peace).		
1817	£7,645,422	19,000
1818	6,547,809	20,000
1819	6,527,781	20,000
1820	6,691,345	23,000
1821	£6,382,786	
1822	5,943,879	
1823	5,193,642	
1824	5,613,151	
1825	6,161,818	
1826	5,849,119	
1827	6,540,634	
1828	6,414,727	
1829	5,667,969	
1830	5,902,339	
1831	5,309,605	
1832	5,689,858	
1833	4,882,835	
1834	4,360,235	
1835	4,503,908	
1836	4,099,429	
1837	4,205,726	
1838	4,750,658	
1839	4,520,428	
1840	5,490,204	
1841	5,597,511	
1842	6,489,074	
1843	6,640,163	

Year	Seamen and Marines.
1844	6,606,056
1845	5,858,219
1846	6,809,872
1847	7,803,464
1848	8,013,873
1849	7,922,286
1850	6,942,397
1851	6,437,883
1852	5,849,916
1853	6,625,943
1854	7,488,000
1855	14,490,105
(War with Russia).	
1856	£19,654,585
(Besides vote of credit).	
1857	£13,459,013
1858	10,590,000
1859	9,215,487
1860	11,823,859
1861	13,331,668
1862	12,598,042
1863	10,491,596
1864	11,028,253
1865	10,449,788
1866	10,626,101
1867	11,477,076
1868	11,701,872
1869	9,403,835
1870	9,776,641
1871	9,750,530
1872	9,900,486
1873	9,656,174
1874	10,179,485
1875	10,785,000
1876	11,289,000
1877	10,979,829
1878	11,053,000
1879	10,586,903
1880	10,310,635
1881	—

TABULAR STATEMENT OF THE TRADE AND NAVIGATION OF THE UNITED KINGDOM.

Years	Imports	Exports		Tonnage of Vessels		
	Total Value	Value of British Products	Total Value of British and Foreign and Colonial Produce	Sailing	Steam	Total
	£	£	£	Tons	Tons	Tons
1861	217,485,024	125,102,814	159,632,498	4,300,518	506,308	4,806,826
1862	225,716,976	123,992,264	166,168,134	4,396,509	537,891	4,934,400
1863	248,919,020	146,602,342	196,902,409	4,731,217	596,856	5,328,073
1864	274,952,172	160,449,053	212,619,614	4,930,219	697,281	5,627,500
1865	271,072,285	165,835,725	218,831,576	4,936,776	823,533	5,760,309
1866	295,290,274	188,917,536	238,905,682	4,903,652	875,685	5,779,337
1867	275,183,137	180,961,923	225,802,529	4,852,911	901,062	5,753,973
1868	294,693,608	179,677,812	227,778,454	4,878,233	902,297	5,780,530
1869	295,460,214	189,953,957	237,015,052	4,765,304	948,367	5,713,671
1870	303,257,493	199,586,322	244,080,577	4,577,855	1,112,934	5,690,789
1871	331,015,480	223,066,162	203,574,700	4,374,511	1,319,612	5,694,123
1872	354,693,624	256,257,347	314,588,834	4,213,295	1,538,032	5,751,327
1873	371,287,372	255,164,603	311,004,765	4,091,379	1,713,783	5,805,162
1874	370,082,701	239,558,121	297,650,464	4,108,220	1,870,611	5,978,831
1875	373,939,577	223,465,963	281,612,323	4,206,897	1,945,570	6,152,467
1876	375,154,703	200,639,204	256,776,602	4,257,986	2,005,347	6,263,333
1877	394,419,682	198,893,065	252,346,020	4,260,639	2,139,170	6,390,869
1878	368,770,742	192,848,914	245,483,858	4,238,692	2,316,472	6,555,164
1879	362,991,875	191,531,758	248,783,364	4,068,742	2,511,233	6,579,975
1880	411,229,565	223,060,446	286,414,466	3,851,045	2,723,468	6,574,513

Navy Estimates, Effective and Non-Effective.

Year	Effective Service (Total) Including Votes 6 and 1	Votes 6 and 10 (secs. 1 and 2)	Non-Effective Service (Total)	Total of the Navy Esimates
	£	£	£	£
1861-62	11,289,745	—	1,350,843	12,640,588
1862-63	10,416,679	—	1,377,626	11,794,305
1863-64	9,338,654	—	1,397,378	10,736,032
1864-65	9,320,902	—	1,381,974	10,708,651
			5,775	
1865-66	8,978,785	—	1,413,439	10,392,224
1866-67	8,990,286	2,718,472	1,444,449	10,434,735
1867-68	9,523,734	3,091,438	1,452,519	10,976,253
1868-69	9,683,179	3,208,970	1,474,111	11,157,290
1869-70	8,481,116	2,654,646	1,515,525	9,996,641
1870-71	7,545,630	2,123,615	1,824,900	9,370,530
1871-72	8,116,696	2,557,099	1,775,260	9,891,956
1872-73	7,576,027	2,384,609	1,766,122	9,532,149
1873-74	8,202,599	2,901,826	1,802,126	10,004,725
1874-75	8,624,179	3,257,164	1,815,926	10,440,105
1875-76	8,969,373	3,516,027	1,855,821	10,825,194
1876-77	9,400,088	3,938,670	1,896,784	11,296,872
1877-78	9,086,912	3,590,980	1,920,717	11,007,629
1878-79	10,163,776	4,000,440	1,966,125	12,129,901
1879-80	8,590,148	3,227,000	1,996,746	10,586,894
1880-81	8,662,132	3,123,585	2,040,803	10,702,935
1881-82	8,833,003	3,302,285	2,062,916	10,895,919

Exports and Imports and Effective Services of the Navy.

Years	Exports and Imports	Tonnage—Steam	Navy Estimates Effective Service
	£	£	£
1861	377,117,522	506,308	11,289,745
1862	391,885,110	537,891	10,416,679
1863	445,821,429	596,856	9,338,654
1864	487,571,786	697,281	9,320,902
1865	489,903,861	823,533	8,978,785
1866	534,195,956	875,685	8,990,286
1867	500,985,666	901,062	9,523,734
1868	522,472,062	902,297	9,683,179
1869	532,475,266	948,367	8,481,116
1870	547,338,070	1,112,934	7,545,630
1871	534,590,180	1,319,612	8,116,696
1872	669,232,458	1,538,032	7,576,027
1873	682,292,137	1,713,783	8,202,599
1874	667,733,165	1,870,611	8,624,179
1875	655,551,900	1,945,570	8,969,373
1876	631,931,305	2,005,347	9,400,088
1877	646,765,702	2,139,170	9,086,912
1878	614,254,600	2,316,472	10,163,776
1879	611,775,239	2,511,233	8,590,148
1880	697,644,031	2,723,468	8,662,132

TABLE IV.

Budgets de la Marine Française.

	Francs	Extraordinaries Francs
1861 . . .	124,588,793	2,058,330
1862 . . .	126,015,419	not found
1863 . . .	126,418,920	16,500,000
1864 . . .	128,586,632	14,500,000
1865 . . .	126,286,632	14,000,000
1866 . . .	127,969,882	36,475,000
1867 . . .	123,269,862	27,193,900
1868 . . .	125,846,482	15,200,000
1869 . . .	136,453,193	21,500,000
1870 . . .	136,129,172	13,400,000
1871 . . .	137,396,755	8,684,621
1872 . . .	125,316,148	5,186,847
1873 . . .	127,763,666	none given
1874 . . .	127,039,498	"
1875 . . .	129,031,691	"
1876 . . .	136,387,481	"
1877 . . .	156,071,811	240,000
1878 . . .	162,961,933	{ 5,753,393 crédit supplémentaire 27,402,000 comte de liquidation
1879 . . .	165,666,182	20,190,884
1880 . . .	163,962,182	19,714,013
1881 . . .	166,089,495	26,270,523

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ITS STRENGTH, RESOURCES, AND ADMINISTRATION.

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